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DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

JOSEPH A. HOLMES, DIRECTOR

A LABORATORY STUDY
OF THE
INFLAMMABILITY OF COAL DUST

BY

J. C. W. FRAZER, E. J. HOFFMAN

AND

L. A. SCHOLL, JR.



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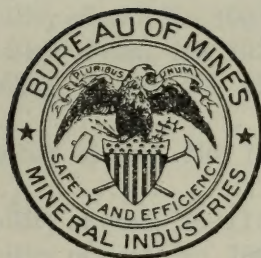
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A LABORATORY STUDY

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FLAMMABILITY OF COAL DUST

First edition, June, 1913.

J. C. W. TRASK & J. H. HOPKINS

U. S. GEOLOGICAL SURVEY



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A LABORATORY STUDY OF THE INFLAMMABILITY OF COAL DUST.

By J. C. W. FRAZER, E. J. HOFFMAN, and L. A. SCHOLL, Jr.

INTRODUCTION.

The danger from coal dust in mines has been thoroughly demonstrated by experiment, and consequently the study of the inflammability of coal dust suspended in air, that is, the readiness with which a cloud of coal dust inflames, is of decided importance to those engaged in coal mining. Much knowledge has been gained from the work done in the large galleries constructed at official and semiofficial stations in this country and abroad, but the study of the coal-dust problem in these galleries requires so much time and is so costly that there is need of a reliable laboratory method for obtaining a classification of the great variety of dusts that occur in mines. The investigation described in this paper was an attempt to devise such a method. It was a preliminary investigation, and work in the same direction is being continued by the Bureau of Mines. As Mr. Frazer has severed his connection with the bureau, it is deemed advisable to publish the results of his study substantially as he prepared them, with little attempt to draw conclusions or to show the bearing of the results on other studies now in progress. The results of these studies and a full discussion of the significance of the laboratory investigations will be published in future reports of the Bureau of Mines.

The reader should remember that any laboratory method, since it involves conditions that differ so greatly from those of actual mining, should be thoroughly tested, and the results obtained by it should be confirmed by experiments conducted on a scale simulating mining conditions before final conclusions are drawn.

The need of a laboratory method has long been felt, and several investigators have devised apparatus and methods. The work done by Vital, Holtzworth and Von Meyer, Bedson and Widdas, Le Châtelier, and that of the British Coal Dust Commission is of great interest in this connection. Bureau of Mines Bulletin 20^a contains a sum-

^a Rice, G. S., The explosibility of coal dust, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz: Bull. 20, Bureau of Mines, 1911, 204 pp.

WORK BY THE BUREAU OF MINES.

DESCRIPTION OF APPARATUS.

The apparatus that was used by the authors in the present investigations is shown in figure 2. It consists essentially of the explosion flash *a*, the platinum coil *i*, and devices for putting the dust in suspension and for measuring the pressure developed in *a*.

The flask *a*, which has a capacity of 1,600 c. c., is provided with large tubulures at its top and bottom; the ends of these tubulures are ground true on a glass plate with emery powder. Experience indicates that a flask with a capacity of about 1,250 c. c. would

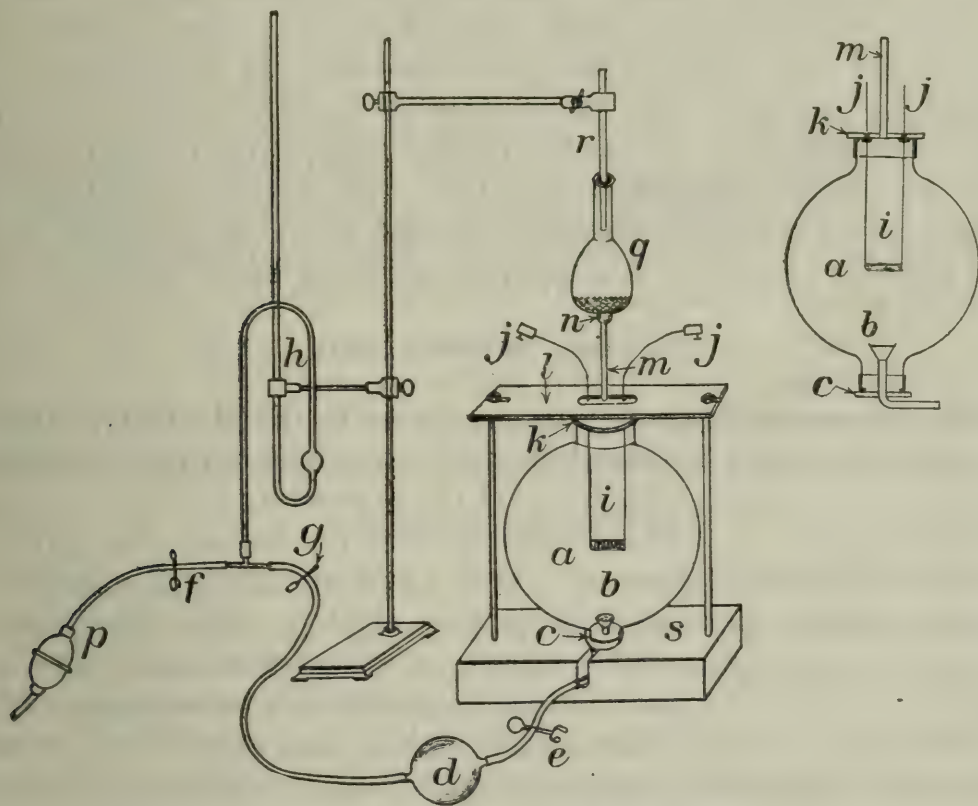


FIGURE 2.—Apparatus used by the Bureau of Mines.

probably be preferable. The brass plate k , which rests on the end of the top tubulure, carries the platinum coil i and the brass tube m . The brass plate c , on which a rests, carries the small glass funnel b , which is cemented gas-tight into c . The contact between the ends of a and the brass plates k and c is made gas-tight by wide rubber bands, which are placed around the end of each tubulure and left projecting a short distance. The contraction of the rubber draws the projecting portion down on the ends, forming a rubber cushion between the ends of the tubulures and the brass plates, and by screwing down the nuts above the steel piece l , the joints at these points are made tight. The platinum coil i is suspended near the center of a by the two stout nickel leads j, j , which pass through fiber

plugs in *k*. The coil *i* is made of about 100 cm. of No. 26 platinum wire, wound on a quartz-glass frame, which is attached as described above to the leads *j*, *j*. The steel ball *n* is ground to fit practically gas tight on top of *m*, which is soldered to *k* and communicates with *a*.

The dust to be investigated is weighed into the glass funnel *b* and at each trial is brought to about the same position in the stem of the funnel, which is then connected by means of a short rubber tube to the 150-c. c. glass bulb *d*. By means of the compression bulb, *p*, the air in *d* is compressed until a pressure of 150 mm. of mercury is indicated by the manometer *h*. At the proper instant the dust in *b* is ejected and put in suspension in *a* by suddenly opening the pinch cock *e*. In order to insure a more uniform dissemination of the dust in *a*, *b* is covered with a small piece of 18-mesh copper gauze. By blowing the dust through the gauze the adhering particles are more completely separated and the density of the dust cloud in *a* is rendered more uniform. It has been found inadvisable to use the gauze on *b*, except with samples of coal dust. The pressure developed in *a* is determined by ascertaining by several trials the smallest weight that must be placed on *n* to prevent its being lifted from *m*.

METHOD OF OPERATION.

With the apparatus connected as shown in the illustration (fig. 2), the desired current is passed through the platinum coil for exactly 3 minutes, and during this interval the expanding air in *a* is released at intervals of 1, 2, and $2\frac{3}{4}$ minutes after the instant the current is first passed through the coil. At the end of exactly 3 minutes *e* is quickly opened and the dust in *b* is ejected. The experiment is repeated several times, the weight on *n* being varied each time until it is found that the pressure developed in *a* lies between two values differing by 5 grams. The weight, which is a small flask or other glass vessel containing mercury, is easily varied. In every experiment 0.05 gram of dust was used for ignition, as with this quantity it has been found that the most inflammable coals are still able to exert the maximum explosive force.

In order to obtain comparable results, the conditions must be kept uniform in every particular. A 220-volt power-house current was used in these experiments, its voltage being reduced by suitable resistance before it passed to the coil *i*. An ammeter was always in circuit, and the current was kept as steady as possible by means of a rheostat, but frequently the current was so unsteady that some tests had to be repeated several times before the results were satisfactory. This was especially true when conditions within the flask were just about those required for the complete ignition of the dust. Hence, a storage battery should be used as the source of the current.

Experiments were made on each dust with current strengths of 5, 5.5, 6, 6.5, and 7 amperes. The temperature corresponding to each of these intervals could not be readily determined, but the resistance of the coil at each interval was determined, as follows:

Resistance of coil with different strengths of current.

Amperes.....	5.0	5.5	6.0	6.5	7.0
Ohms.....	3.6	3.74	3.85	3.90	3.97

PREPARATION OF THE SAMPLE.

Previous experiments had shown that when the particles are below a certain size the fineness of the particles has a decided effect on the inflammability of a dust. But it was considered better to grind all of the samples so fine that the whole of each sample introduced would take part in the action within the flask than to attempt to separate and collect the finest dust by screening, as the finest dust might have a composition different from that of the sample as a whole. In all of the tests recorded in this paper the whole of each sample was air dried to constant weight and then ground fine enough to pass through a 200-mesh sieve, the fineness of all the samples being as nearly as possible the same. Some samples undoubtedly contained more extremely fine dust than did others, but it is not believed that this finest part and that which just passes a 200-mesh screen would differ much in inflammability under the conditions of these experiments.

ACKNOWLEDGMENTS.

The samples were collected under the supervision of G. S. Rice, chief mining engineer, who took much interest in the investigation and was consulted frequently by the authors during its progress.

The samples were analyzed under the direction of A. C. Fieldner, chemist. The methods used were those adopted by the Bureau of Mines.^a The authors are much indebted to Mr. Fieldner and his assistants for the preparation and analysis of the samples.

STATEMENT OF RESULTS.

In the following tables are given the results of the investigation. All of the experiments were made under the same conditions, except those with artificial mixtures (Table 4 and figs. 71-75), in which an explosion flask of a different size was used. Except for those tests, all results are comparable. In every case the pressure from the air used to put the dust into suspension has been deducted from the pressure caused by the explosion.

In addition to samples of coal dust, some artificial mixtures of coal dust and finely ground shale, also calcium carbonate, have been inves-

^a Stanton, F. M., and Fieldner, A. C., Methods of analyzing coal and coke: Technical Paper 8, Bureau of Mines, 1912, 18 pp.

tigated in order to measure the effectiveness of these substances in diminishing the inflammability of coal dust. The following substances also were investigated: Wood dusts (4 samples), asphalt (4 samples), and gluten, flour, starch, sugar, and lycopodium (1 sample of each).

In order to present the results in a form more convenient than tables, they, with the exception of those for road dusts (Table 3), are shown as curves. The curves are plotted with the strength of current on the coil as abscissas, and the pressures in the flask as ordinates; the maximum weight in grams lifted in a test is taken as the pressure corresponding to the strength of current in that test. Since the diameter of the brass tube m (fig. 2) is 7 mm., the pressure per unit area can be calculated if desired. The heights of any two curves at corresponding points are assumed to be determined by the relative inflammability of the two dusts under the conditions corresponding to the points. The curves of any group of tests are arranged in ascending order according to the increasing inflammability of the samples, as shown by the heights of the curves above the line of zero pressure at the highest current strength used in the coil. Several samples, as the curves show, have about the same inflammability. In such cases the order in which the results are placed is largely a matter of opinion.

The dusts investigated have been divided into four groups, according to their nature as follows: Group 1 (Tables 1 and 2 and figs. 3-70), samples of coal dust; group 2 (Table 3), samples of road dusts high in ash; group 3 (Table 4 and figs. 71-75), artificial mixtures of dusts with known percentages of shale dust or of calcium carbonate; group 4 (Table 5 and figs. 76-86), inflammable dusts other than coal dusts.

It will be noticed that, in general, the curves are of two types and the dusts of group 1 have been subdivided into two divisions corresponding to the two types of curves. The curves for the samples of the first division rise continuously in a more or less irregular manner with increasing temperature of the coil, whereas those for the second division rise rapidly at first but toward the end of the range covered by these experiments rise little and are practically parallel to the horizontal axis. These results seem to indicate that the samples of the second division of group 1 exerted their maximum explosive force within the range of the tests, whereas those of the first division did not. It seems that many of the samples of the first division did not ignite or that the ignition extended only a short distance into the cloud of dust. In none of the samples of the first division does the ignition seem to have extended throughout the whole cloud, for the curves of this division ascend continuously throughout their whole length, and the maximum explosive force of the samples was not developed within the range of the experiments.

TABLE 1.—*Dusts of group 1A, coals and lignites.*

Laboratory number and description.	Chemical analysis (air-dried sample).						Inflam- mabil- ity, ^a	Weight lifted at different current strengths.					For curve see fig. No. —
	Mois- ture.	Volatile matter.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.	
10900. Montana, Valley County, 7 miles NW. of Mondak; outcrop; lignite.	P. ct. 12.49	P. ct. 40.65	P. ct. 40.75	P. ct. 6.11	P. ct. 0.56	P. ct. 33.45	P. ct. 1.15	Grams.	Grams.	Grams. 5	Grams. 13	Grams. 25	3
11680. West Virginia; McDowell County; Berwind mine; Pocahontas bed; semibituminous coal.	.53	16.22	71.39	11.86	2.16	.....	.....	.....	5	8	18	38	4
11360. Pennsylvania; Cambria County; Portage Station; Mil- ler shaft No. 1; Miller bed; semibituminous coal.	.68	18.03	74.86	6.43	1.25	3.16	1.26	.....	5	15	28	58	5
11361. Montana, Dawson County, 9 miles NW. of Glendive; Dick mine; A bed; lignite.	17.78	31.51	44.21	6.50	.47	.....	.....	.....	8	13	33	63	6
10630. West Virginia, Raleigh County; Raleigh; mine No. 2; Bechley bed; semibituminous coal.	.51	18.41	77.40	3.68	.64	3.49	1.60	.....	8	13	38	63	7
10629. West Virginia, Fayette County; Thayer; Slater-Buf- falo mine; Fire Creek bed; semibituminous coal.	.69	18.93	72.68	7.70	1.10	3.82	1.60	.....	8	18	48	85	8
10628. West Virginia, Raleigh County; Raleigh; mine No. 3; Bechley bed; semibituminous coal.	.59	18.77	77.01	3.63	.74	3.38	1.55	.....	8	18	38	103	9
10623. West Virginia, Fayette County; South Nuttall; Brown mine; Sewell bed; semibituminous coal.	.83	25.45	70.91	2.81	.60	4.62	1.61	.....	13	18	33	133	10
10732. Colorado, El Paso County; Calhan; Mosby mine; Mosby bed; subbituminous coal.	15.57	32.77	34.12	17.54	.38	28.92	.86	16	28	68	93	133	11
11135. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.00	28.90	55.78	14.32	.63	6.91	1.16	.....	13	28	113	133	12
11134. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.28	29.39	56.00	13.33	.57	8.00	1.16	.....	13	18	123	143	13
11107. Colorado, Delta County; Dominguez; Wells Gulch mine; — bed; bituminous coal.	2.57	31.41	48.59	17.43	1.90	.....	.....	.....	8	13	138	143	14

^a The relative inflammability of the dusts is based on the results of the tests in which the greatest current strength was on the wire (see p. 8), and the dust least inflammable with that current strength under the conditions of the tests is ranked 1 in this table.

TABLE 1.—*Dusts of group 1A, coals and lignites—Continued.*

Laboratory number and description.	Chemical analysis (air-dried sample).							Inflam- mabil- ity.	Weight lifted at different current strengths.					For curve see fig. No.—
	Mois- ture.	Volatile matter.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.	Nitro- gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.	
10692. Tennessee, Rhea County; Dayton; North Pole-Richland mine; Richland bed; bituminous coal.	P. ct. 1.07	P. ct. 29.05	P. ct. 57.98	P. ct. 11.90	P. ct. 1.80	P. ct. 5.13	P. ct. 1.27	13	Grams.	Grams. 18	Grams. 38	Grams. 153	Grams. 153	15
12198. Colorado, Las Animas County; Starkville; Starkville mine; Starkville bed; bituminous coal.	1.22	29.23	52.77	16.78	.56	6.81	1.11	14	8	18	28	145	163	16
11059. Wyoming, Johnson County, 50 miles north of Casper; open bank; subbituminous coal.	13.63	32.61	38.19	15.57	1.60	25.66	1.04	15	8	43	93	138	168	17
12086. Alabama, Jefferson County; Littleton; Banner mine; Big or Mary Lee bed; bituminous coal.	1.15	27.32	60.32	11.21	.80	6.17	1.61	16	.....	15	23	128	170	18
11443. Colorado, Las Animas County; Delagua; Delagua mine; Delagua bed; bituminous coal.	1.24	35.08	53.14	10.54	.56	9.42	1.41	17	.....	25	48	135	175	19
10801. Tennessee, Bledsoe County; Litton; Thurman mine; Richland bed; bituminous coal.	1.06	27.29	64.21	7.44	.53	.....	.....	18	.....	13	20	143	178	20
11163. Pennsylvania, Washington County, Monongahela City; Catsburg mine; Pittsburgh bed; bituminous coal.	1.05	34.12	58.34	6.49	1.13	7.18	1.35	19	.....	18	28	153	178	21
11170. Pennsylvania, Washington County; Band Station; Schoenberger mine; Pittsburgh bed; bituminous coal.	1.07	34.55	58.51	5.87	1.07	6.97	1.41	20	.....	18	33	153	183	22
11156. West Virginia, Marion County; Worthington; Hutchinson mine; Pittsburgh bed; bituminous coal.	1.22	36.39	53.58	8.81	2.06	6.98	1.27	21	.....	23	48	160	188	23
12029. Colorado, Las Animas County; Hastings; Hastings mine; Hastings bed; bituminous coal.	.83	32.77	49.09	17.31	.94	8.10	1.22	22	.....	23	40	178	190	24
10741. Colorado, El Paso County, 3 miles SW. of Ramah; Purdon mine; Purdon bed; subbituminous coal.	11.31	31.36	32.98	24.35	.43	25.41	.72	23	.....	18	73	153	193	25
10713. Utah, Uinta County, 8 miles east of Vernal; Eph Green mine; bituminous coal.	7.75	39.27	44.65	8.33	2.39	.....	.....	24	.....	48	91	183	193	26

11433. West Virginia, Marion County; Monongah; mine No. 63; Pittsburgh bed; bituminous coal.	1.47	35.54	57.30	5.69	.68	7.91	1.40	25	.....	23	55	153	198	27
10916. Tennessee, Bladsoe County; Pikeville; No. 3 mine; Sewanee bed (?); bituminous coal.	1.68	29.92	61.91	6.49	.53	.....	.....	26	.....	18	43	163	198	28
10959. Illinois, Madison County; Collinsville; No. 3 mine; No. 6 bed; bituminous coal.	7.52	38.52	43.93	10.03	3.89	15.01	1.05	27	.....	38	63	168	198	29
11006. Montana, Valley County, 6 miles NE. of Medicine Lake; Jones mine; Jones bed; lignite.	9.36	41.40	40.59	8.65	.62	33.30	1.03	28	8	43	83	188	198	30
11382. Alaska, Matanuska field; outcrop; bituminous coal.	4.76	36.00	53.85	5.39	.24	18.74	1.20	29	.....	25	58	153	203	31
10997. Utah, Wasatch County, 2 miles east of Hanna; Winchester prospect; Mancos bed; subbituminous coal.	10.37	39.68	46.75	3.20	.74	.....	.....	30	8	38	58	163	203	32
11592. Oklahoma, Pittsburg County, 2 miles north of Alderson; Alderson No. 38 mine; McAlester bed; bituminous coal.	1.52	33.28	58.04	7.16	.50	8.67	1.65	31	.....	15	23	183	203	33
12025. Colorado, Las Animas County; Primero; Primero mine; Primero bed; bituminous coal.	.77	31.58	57.57	10.08	.60	6.93	1.68	32	13	33	43	123	208	34
10575. Washington, Pierce County; Carbonado; Carbonado mine No. 4; Carbonado bed No. 4; bituminous coal.	1.68	35.24	48.02	15.06	.35	8.18	1.94	33	8	43	83	178	208	35
11465. Wyoming, Sweetwater County; Thayer Junction; B mine; No. 7 bed; bituminous coal.	4.64	39.96	51.76	3.64	1.07	14.88	1.56	34	.....	23	68	168	213	36
10556. Pennsylvania, Allegheny County; Oak Station; Oak mine; Pittsburgh bed; bituminous coal.	1.90	35.59	57.87	4.64	.52	9.19	1.53	35	8	33	73	173	213	37
10961. Indiana, Sullivan County; Dugger; No. 10 mine; No. 4 bed; bituminous coal.	7.37	34.81	51.79	6.03	1.17	14.95	1.60	36	.....	43	73	188	213	38
11354. Illinois, Montgomery County; Panama; Panama mine; No. 6 bed; bituminous coal.	6.48	36.27	44.60	12.65	4.05	13.83	1.02	37	.....	33	83	188	213	39
11184. Kansas, Crawford County; Fuller; No. 2 shaft; bituminous coal.	1.50	34.71	54.37	9.42	5.12	5.60	1.28	38	.....	13	73	155	218	40
11130. Pennsylvania, Allegheny County; Creighton; Hite mine; Freeport bed; bituminous coal.	1.51	35.22	56.67	6.60	.97	.....	.....	39	.....	43	73	168	218	41
11180. Missouri, Barton County, 1 mile NE. of Minden; Pullen No. 1 mine; bituminous coal.	1.28	33.47	55.91	9.34	3.78	5.60	1.43	40	.....	23	48	203	218	42
11188. Missouri, Barton County, 2 miles NW. of Minden; No. 17 shaft; bituminous coal.	1.64	32.37	53.99	12.00	5.22	6.16	1.14	41	.....	8	53	173	220	43

TABLE 1.—*Dusts of group 1A, coals and lignites—Continued.*

Laboratory number and description.	Chemical analysis (air-dried sample).								Inflam- mabil- ity.	Weight lifted at different current strengths.					For curve see fig. No.—
	Mois- ture.	Volatile matter.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.	Nitro- gen.	5.0 amp.		5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.		
12028. Colorado, Las Animas County; Hastings mine; Hastings bed A; bituminous coal.	P. ct. 1.27	P. ct. 33.18	P. ct. 56.16	P. ct. 9.39	P. ct. 0.63	P. ct. 7.95	P. ct. 1.37	42	Grams. 43	Grams. 100	Grams. 138	Grams. 223	Grams. 223	44	
10960. Indiana, Sullivan County; Dugger; No. 10 mine; No. 4 bed; bituminous coal.	7.20	36.61	50.81	5.38	.88	14.60	1.54	43	.....	83	185	223	223	45	
12004. Kentucky, Pike County; Hellier; Edgewater mine; Upper Elkhorn bed; car sample; bituminous coal.	1.45	35.66	60.18	2.71	.57	8.16	1.43	44	.....	88	208	223	223	46	
11984. Pennsylvania, Allegheny County; Bruceton; experi- mental mine; Pittsburgh bed; bituminous coal.	1.70	35.73	56.32	6.25	1.49	.....	.....	45	.....	98	213	223	223	47	
10739. Virginia, Russell County, 2 miles north of Dante; No. 5 mine; Upper Banner bed; bituminous coal.	.78	36.37	57.45	5.40	.58	5.89	1.45	46	.....	93	198	228	228	48	
10736. Virginia, Russell County, 2 miles north of Dante; No. 2 mine; Upper Banner bed; bituminous coal.	.98	35.60	57.54	5.88	.60	5.25	1.46	47	.....	95	203	228	228	49	
10845. Pennsylvania, Allegheny County; Oak Station; Pitts- burgh bed; bituminous coal.	1.81	35.76	56.41	6.02	1.20	8.95	1.47	48	8	98	198	230	230	50	
11569. Oklahoma, Pittsburg County, 2 miles east of McAles- ter; Bushley No. 5 mine; McAlester bed; bituminous coal.	1.41	34.44	58.87	5.28	.55	7.89	1.72	49	.....	55	163	233	233	51	
11460. Wyoming, Sweetwater County; Thayer Junction; No. 6 mine; No. 1 bed; bituminous coal.	3.88	39.55	52.81	3.76	1.11	15.24	1.38	50	.....	98	203	233	233	52	
11985. Pennsylvania, Allegheny County; Bruceton; experi- mental mine; Pittsburgh bed; bituminous coal.	1.67	35.85	55.73	6.75	1.51	.....	.....	51	.....	98	218	233	233	53	
11983. Pennsylvania, Allegheny County; Bruceton; Experi- mental mine; Pittsburgh bed; bituminous coal.	1.83	35.62	56.69	5.86	1.19	.....	.....	52	.....	103	220	233	233	54	
11919. Oklahoma, Pittsburg County; 1.5 miles SW. of Alderson; Alderson No. 5 mine; McAlester bed; bituminous coal.	1.89	35.69	58.00	4.42	.63	8.59	1.72	53	23	83	203	243	243	55	

11594. Oklahoma, Pittsburg County; 2 miles east of Alderson; Alderson No. 33 mine; McAlester bed; bituminous coal.	1.60	34.06	59.24	5.10	.50	8.54	1.69	54	.....	13	68	208	243	56
11658. Utah, Wasatch County; 28 miles S.E. of Neber; E. J. Cammins mine (abandoned); subbituminous coal.	14.35	39.24	39.83	6.58	.73	.....	.....	55	.....	13	113	233	243	57
11930. Colorado, Las Animas County; Forbes; Forbes No. 9 mine; Walsen bed; bituminous coal.	.86	31.07	57.39	10.68	.62	6.14	1.33	56	13	23	68	208	248	58
10189. Colorado, Huerfano county; 9 miles from Walsenberg; Pinon mine; Cameron bed; bituminous coal.	4.83	37.81	49.61	7.75	.57	.....	.....	57	43	88	148	228	248	59
10009. Utah, Carbon County; Hiawatha; Hiawatha No. 2 mine; Hiawatha bed (?); bituminous coal.	3.33	41.79	47.76	7.12	.57	13.89	1.42	58	23	103	133	263	263	60

TABLE 2.—*Dusts of group 1B, chiefly subbituminous coals.*

Laboratory number and description.	Chemical analysis (air-dried sample).							Inflam- mabil- ity. ^a	Weight lifted at different current strengths.					For curve see fig. No.—
	Mois- ture.	Volatile mater.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.	Nitro- gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.	
10671. Wyoming, Natrona County, 25 miles SW. of Casper; White Ash mine; subbituminous coal.	P. ct. 12.21	P. ct. 34.22	P. ct. 46.89	P. ct. 6.68	P. ct. 0.59	P. ct.	P. ct.	1	Grams. 18	Grams. 68	Grams. 138	Grams. 175	Grams. 188	61
10596. Montana, Valley County, 15 miles east of Medicine Lake; Belgon mine; lignite.	11.18	38.82	42.70	7.30	.54	29.85	0.99	2	13	58	163	220	228	62
10998. Utah, Wasatch County, 12 to 15 miles SW. of Hanna; subbituminous coal.	6.14	42.29	45.04	6.53	.90	.....	.....	3	53	103	183	235	253	63
10810. Wyoming, Sheridan County; Acme No. 2 mine, "Carney vein"; subbituminous coal.	15.17	35.31	45.82	3.70	.40	29.32	1.09	4	.....	138	188	228	258	64
10827. Wyoming, Johnson County, 65 miles north of Casper; subbituminous coal.	15.52	39.34	39.43	5.71	.64	30.37	.77	5	48	143	203	243	258	65
10825. Wyoming, Sheridan County; Acme No. 1 mine, "Carney vein," subbituminous coal.	13.49	36.33	45.10	5.08	.34	27.93	1.22	6	43	133	203	238	263	66
11048. Wyoming, Converse County, 29 miles north of Glen- rock; open bank; subbituminous coal.	16.08	36.91	41.62	5.39	.53	31.10	.81	7	73	143	188	253	273	67
10822. Wyoming, Sheridan County; Kooi; Kooi mine; Mon- arch bed; subbituminous coal.	13.94	35.12	45.44	5.50	.56	28.36	1.08	8	.....	138	213	243	278	68
12006. Wyoming, Sheridan County; Monarch; Monarch mine; Monarch bed; subbituminous coal.	14.90	37.28	43.82	4.00	.43	28.11	1.14	9	58	125	208	243	288	69
12008. Wyoming, Sheridan County; Monarch; Monarch mine; Monarch bed; subbituminous coal.	14.97	35.24	46.22	3.57	.41	28.47	1.21	10	.....	138	208	253	308	70

^a The relative inflammability of the dusts is based on the results of the tests in which the greatest current strength was on the wire (see p. 8), and the dust least inflammable with that current strength under the conditions of the tests is ranked 1 in this table.

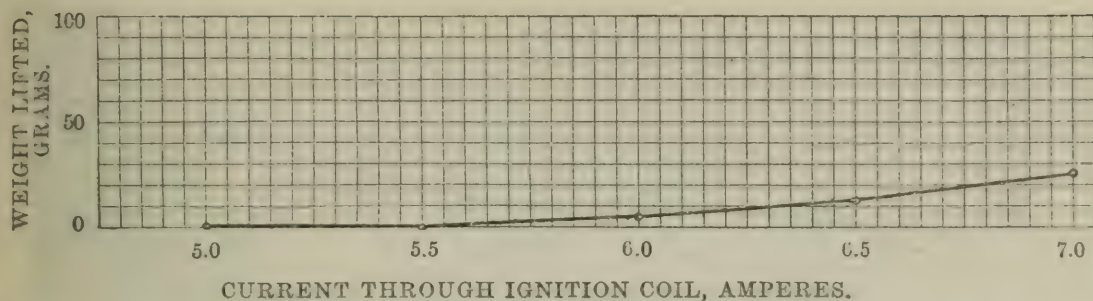


FIGURE 3.—Relative inflammability of coal No. 10900, Valley County, Mont. Moisture, 12.49 per cent; volatile matter, 40.65 per cent; fixed carbon, 40.75 per cent; ash, 6.11 per cent; sulphur, 0.56 per cent.

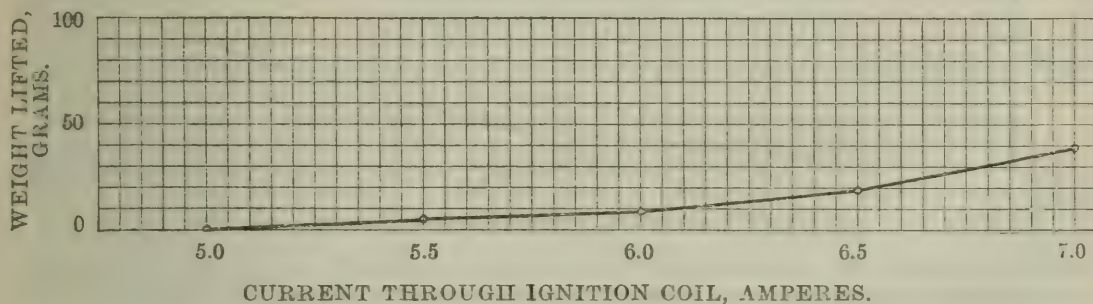


FIGURE 4.—Relative inflammability of coal No. 11680, McDowell County, W. Va. Moisture, 0.53 per cent; volatile matter, 16.22 per cent; fixed carbon, 71.39 per cent; ash, 11.86 per cent; sulphur, 2.16 per cent.

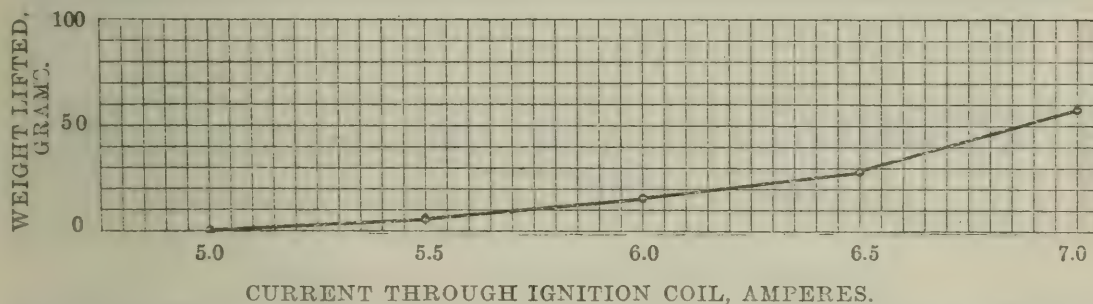


FIGURE 5.—Relative inflammability of coal No. 11360, Cambria County, Pa. Moisture, 0.68 per cent; volatile matter, 18.03 per cent; fixed carbon, 74.86 per cent; ash, 6.43 per cent; sulphur, 1.25 per cent.

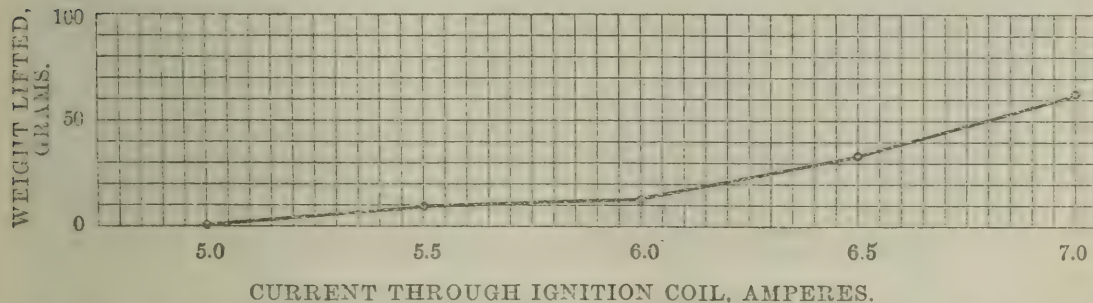


FIGURE 6.—Relative inflammability of coal No. 11361, Dawson County, Mont. Moisture, 17.78 per cent; volatile matter, 31.51 per cent; fixed carbon, 44.21 per cent; ash, 6.50 per cent; sulphur, 0.17 per cent.

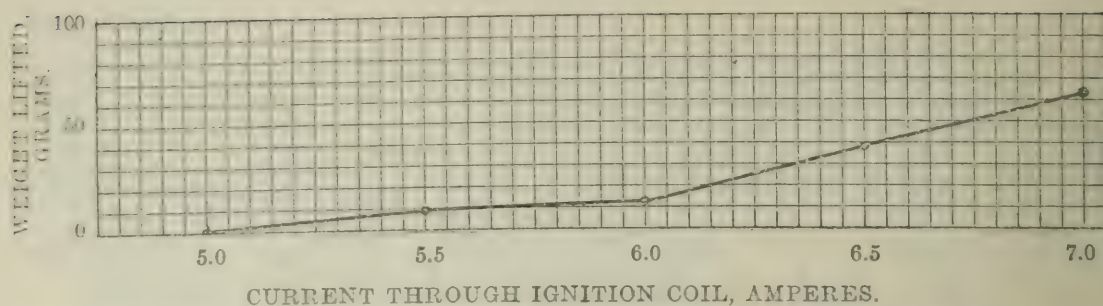


FIGURE 7.—Relative inflammability of coal No. 10630, Raleigh County, W. Va. Moisture, 0.51 per cent; volatile matter, 18.41 per cent; fixed carbon, 77.40 per cent; ash, 3.68 per cent; sulphur, 0.64 per cent.

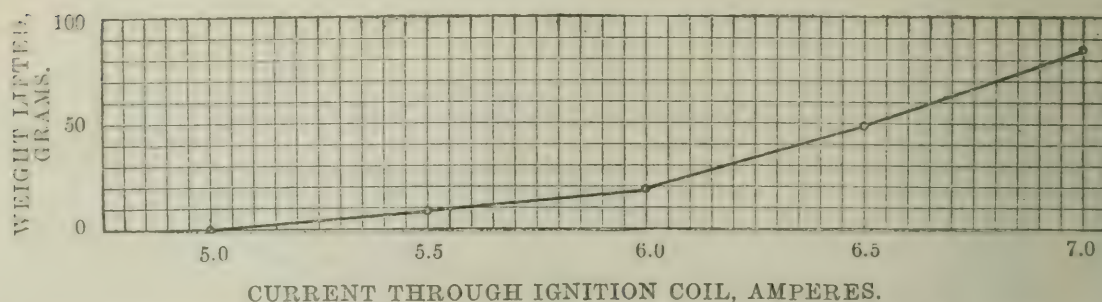


FIGURE 8.—Relative inflammability of coal No. 10629, Fayette County, W. Va. Moisture, 0.69 per cent; volatile matter, 18.93 per cent; fixed carbon, 72.68 per cent; ash, 7.70 per cent; sulphur, 1.10 per cent.

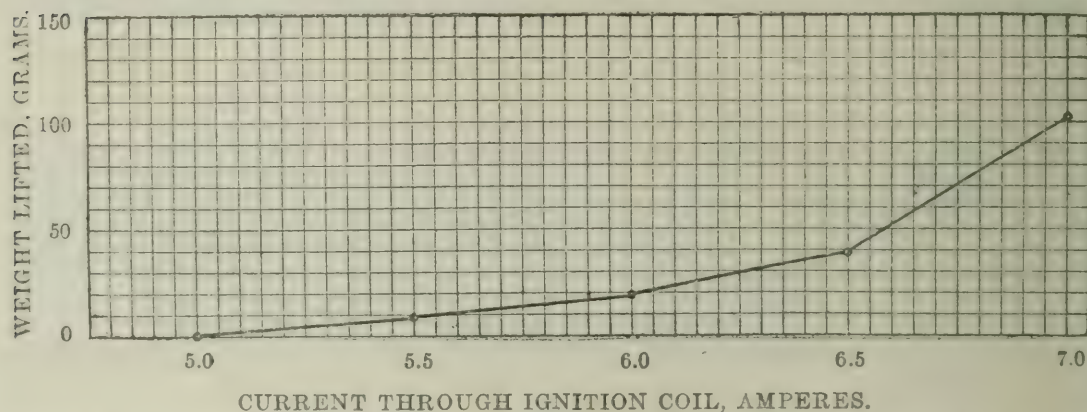


FIGURE 9.—Relative inflammability of coal No. 10628, Raleigh County, W. Va. Moisture, 0.59 per cent; volatile matter, 18.77 per cent; fixed carbon, 77.01 per cent; ash, 3.63 per cent; sulphur, 0.74 per cent.

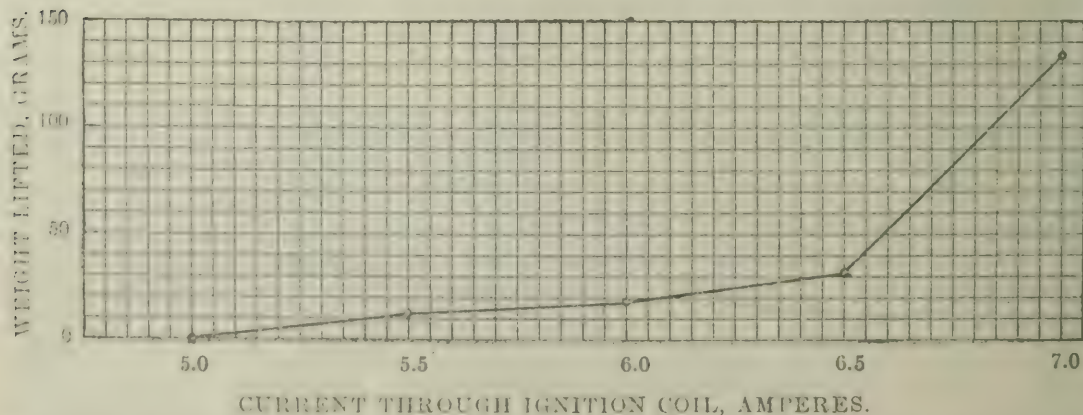


FIGURE 10.—Relative inflammability of coal No. 10623, Fayette County, W. Va. Moisture, 0.83 per cent; volatile matter, 25.45 per cent; fixed carbon, 70.91 per cent; ash, 2.81 per cent; sulphur, 0.60 per cent.

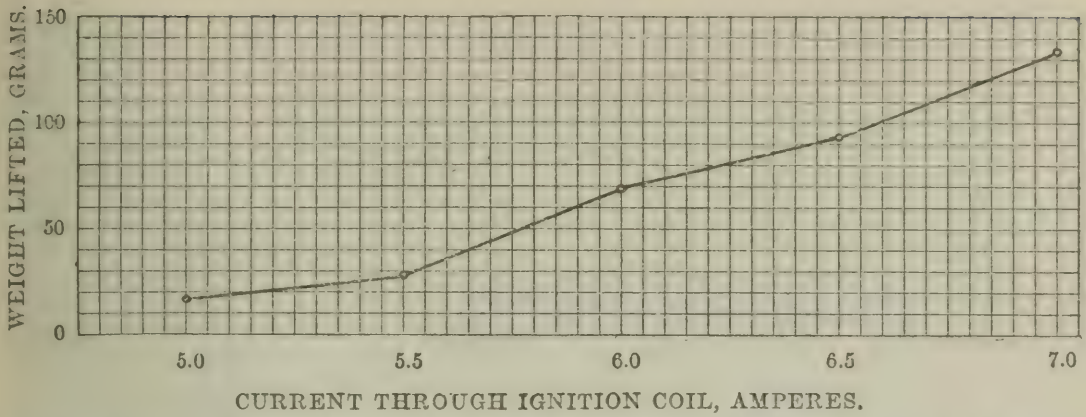


FIGURE 11.—Relative inflammability of coal No. 10732, El Paso County, Colo. Moisture, 15.57 per cent; volatile matter, 32.77 per cent; fixed carbon, 34.12 per cent; ash, 17.54 per cent; sulphur, 0.38 per cent.

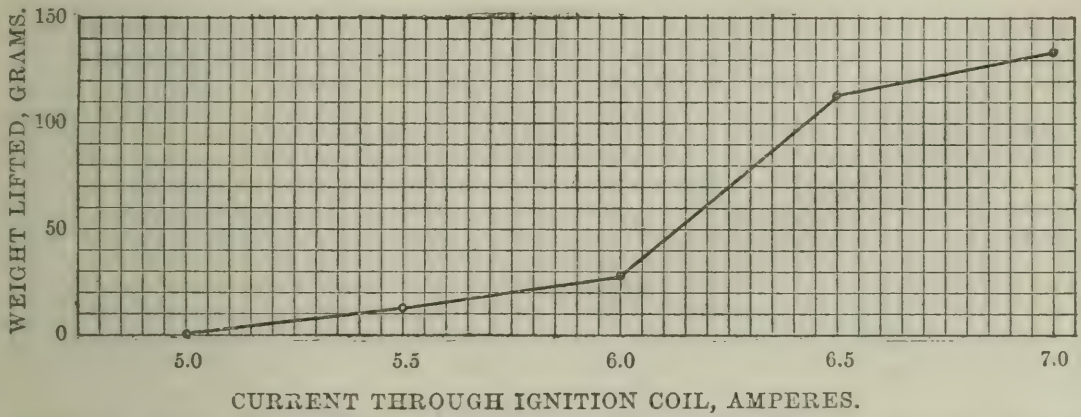


FIGURE 12.—Relative inflammability of coal No. 11135, Las Animas County, Colo. Moisture, 1 per cent; volatile matter, 23.90 per cent; fixed carbon, 55.78 per cent; ash, 14.32 per cent; sulphur, 0.63 per cent.

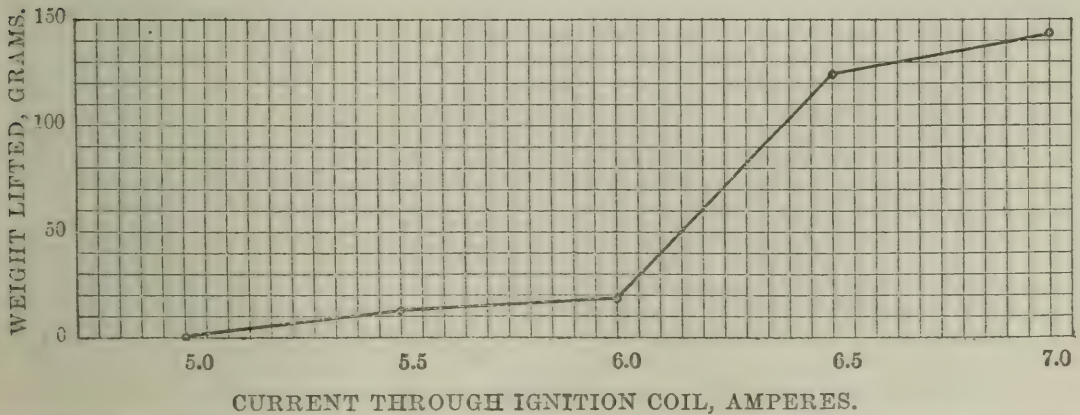


FIGURE 13.—Relative inflammability of coal No. 11134, Las Animas County, Colo. Moisture, 1.28 per cent; volatile matter, 29.39 per cent; fixed carbon, 56.00 per cent; ash, 13.33 per cent; sulphur, 0.57 per cent.

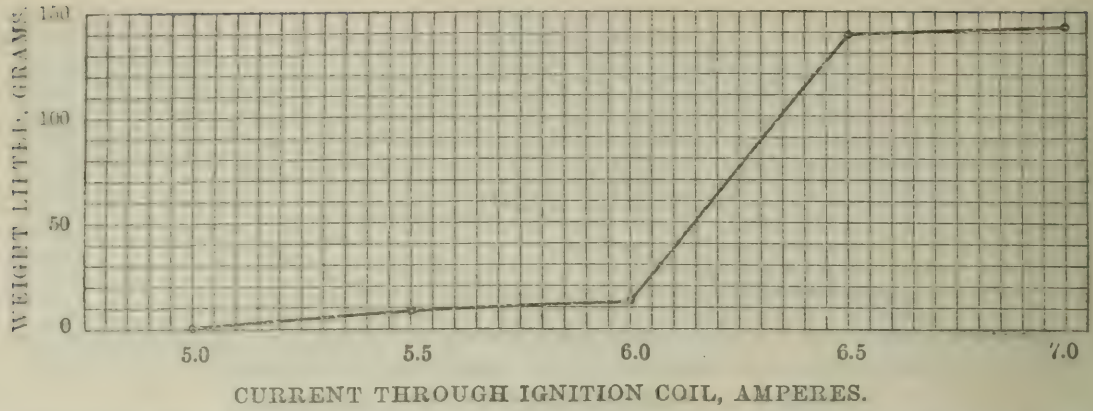


FIGURE 14.—Relative inflammability of coal No. 11107, Delta County, Colo. Moisture, 2.57 per cent; volatile matter, 31.41 per cent; fixed carbon, 48.59 per cent; ash, 17.43 per cent; sulphur, 1.90 per cent.

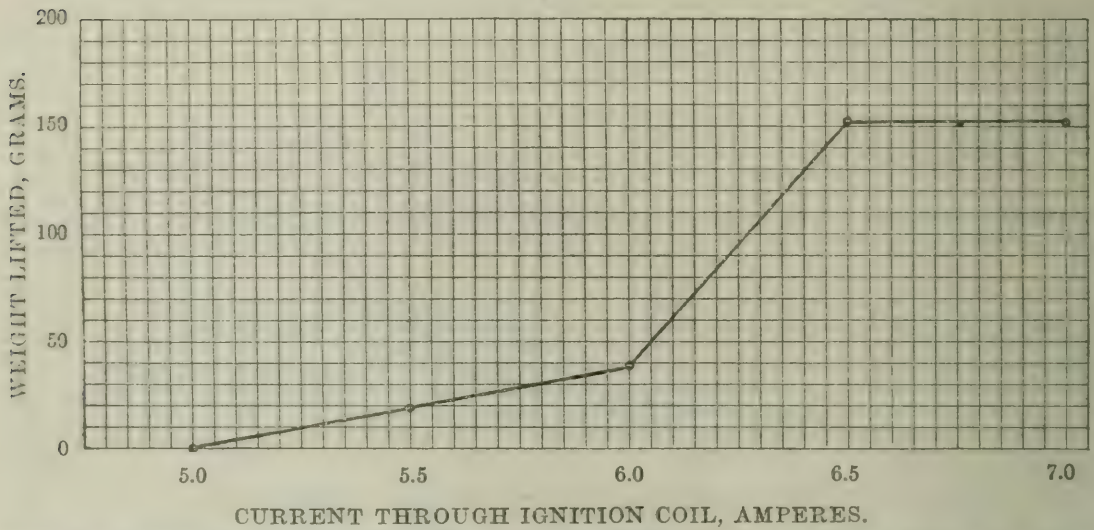


FIGURE 15.—Relative inflammability of coal No. 10692, Rhea County, Tenn. Moisture, 1.07 per cent; volatile matter, 29.05 per cent; fixed carbon, 57.98 per cent; ash, 11.90 per cent; sulphur, 1.80 per cent.

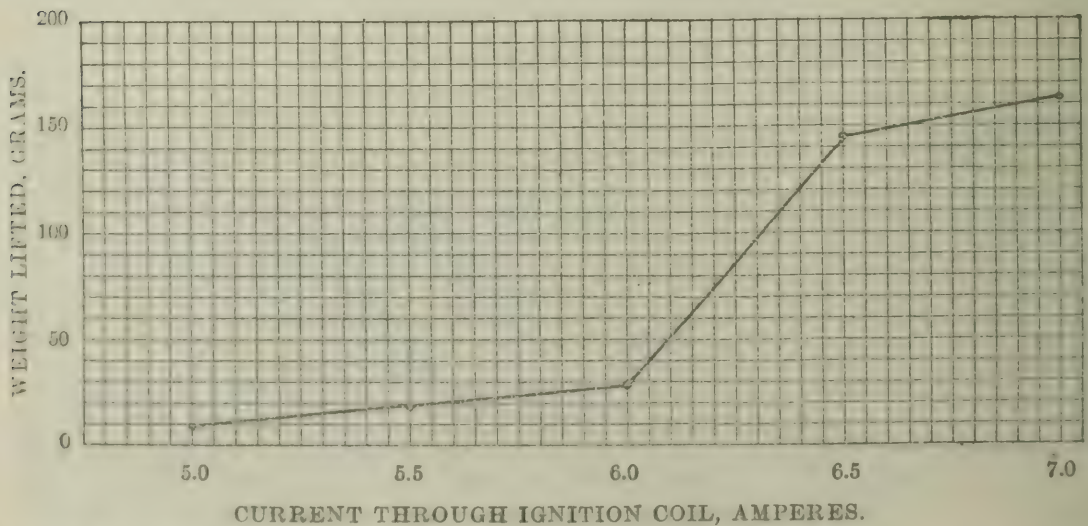


FIGURE 16.—Relative inflammability of coal No. 12198, Las Animas County, Colo. Moisture, 1.22 per cent; volatile matter, 29.23 per cent; fixed carbon, 52.77 per cent; ash, 16.78 per cent; sulphur, 0.56 per cent.

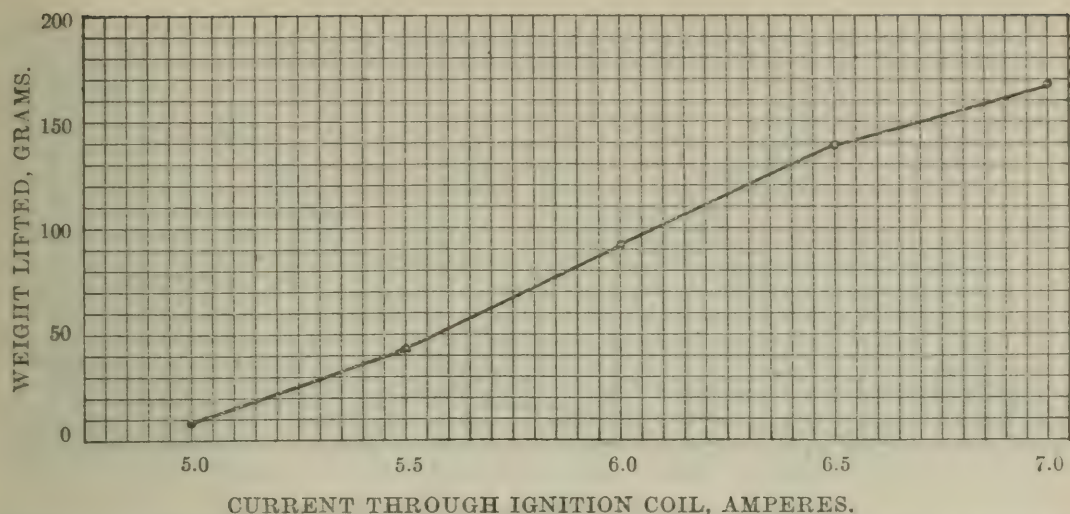


FIGURE 17.—Relative inflammability of coal No. 11059, Johnson County, Wyo. Moisture, 13.63 per cent; volatile matter, 32.61 per cent; fixed carbon, 38.19 per cent; ash, 15.57 per cent; sulphur, 1.00 per cent.

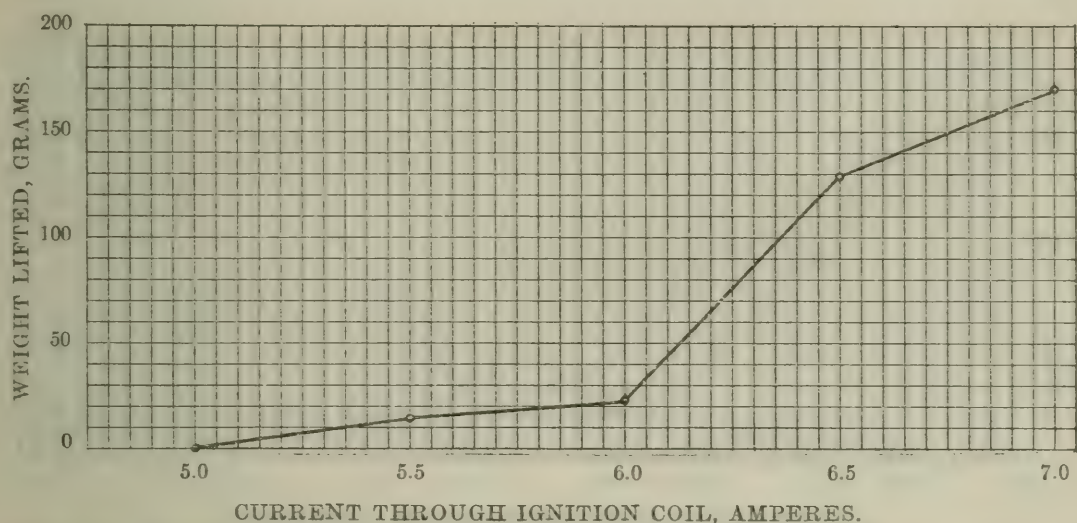


FIGURE 18.—Relative inflammability of coal No. 12086, Jefferson County, Ala. Moisture, 1.15 per cent; volatile matter, 27.32 per cent; fixed carbon, 60.32 per cent; ash, 11.21 per cent; sulphur, 0.80 per cent.

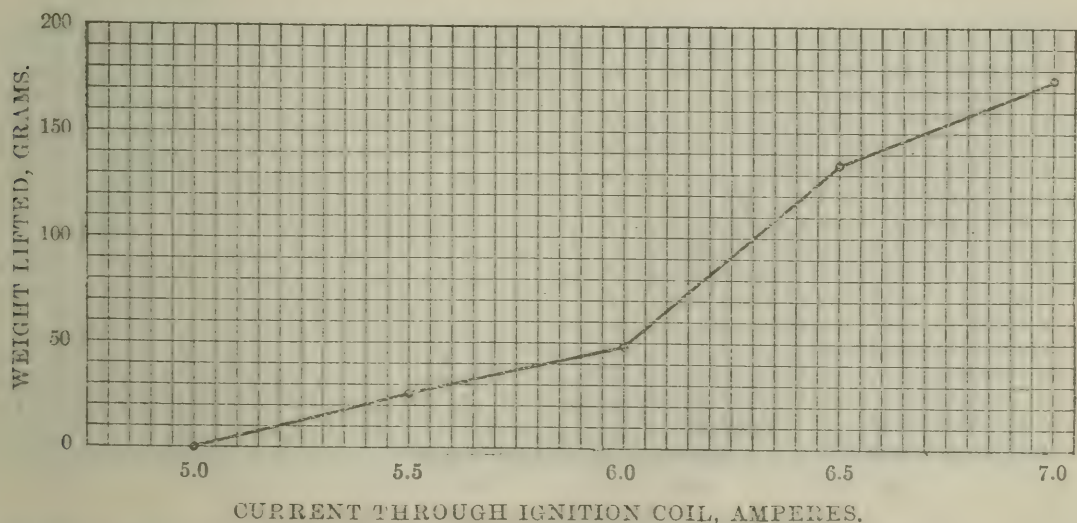


FIGURE 19.—Relative inflammability of coal No. 11443, Las Animas County, Colo. Moisture, 1.24 per cent; volatile matter, 35.08 per cent; fixed carbon, 53.14 per cent; ash, 10.54 per cent; sulphur, 0.86 per cent.

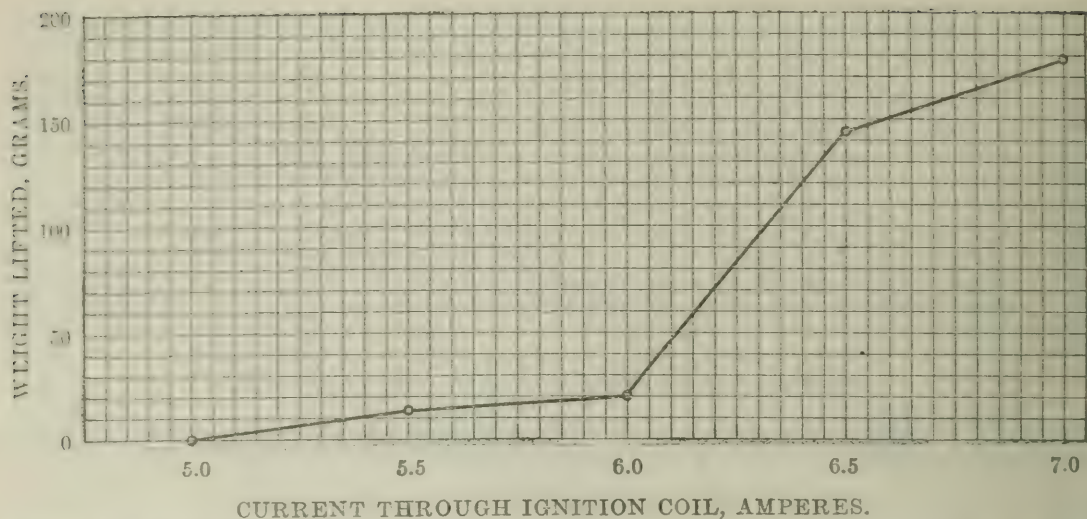


FIGURE 20.—Relative inflammability of coal No. 10801, Bledsoe County, Tenn. Moisture, 1.06 per cent; volatile matter, 27.29 per cent; fixed carbon, 64.21 per cent; ash, 7.44 per cent; sulphur, 0.53 per cent.

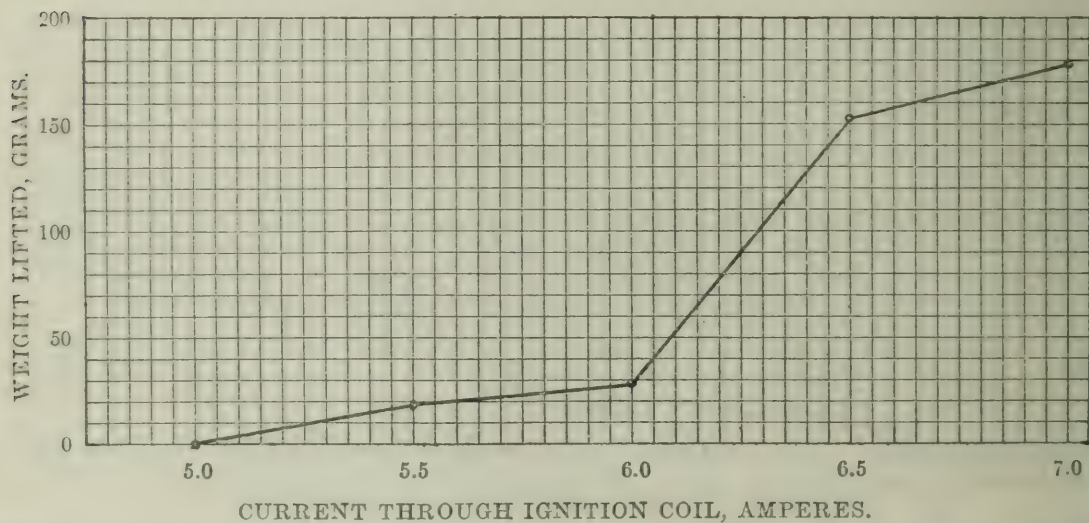


FIGURE 21.—Relative inflammability of coal No. 11163, Washington County, Pa. Moisture, 1.05 per cent; volatile matter, 34.12 per cent; fixed carbon, 58.34 per cent; ash, 6.49 per cent; sulphur, 1.13 per cent.

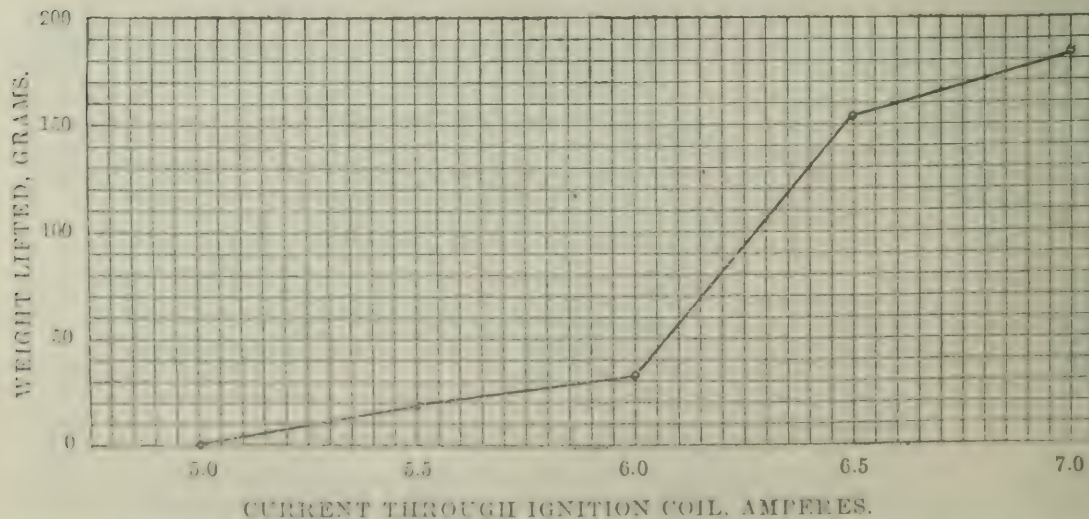


FIGURE 22.—Relative inflammability of coal No. 11170, Washington County, Pa. Moisture, 1.07 per cent; volatile matter, 34.55 per cent; fixed carbon, 58.51 per cent; ash, 5.87 per cent; sulphur, 1.07 per cent.

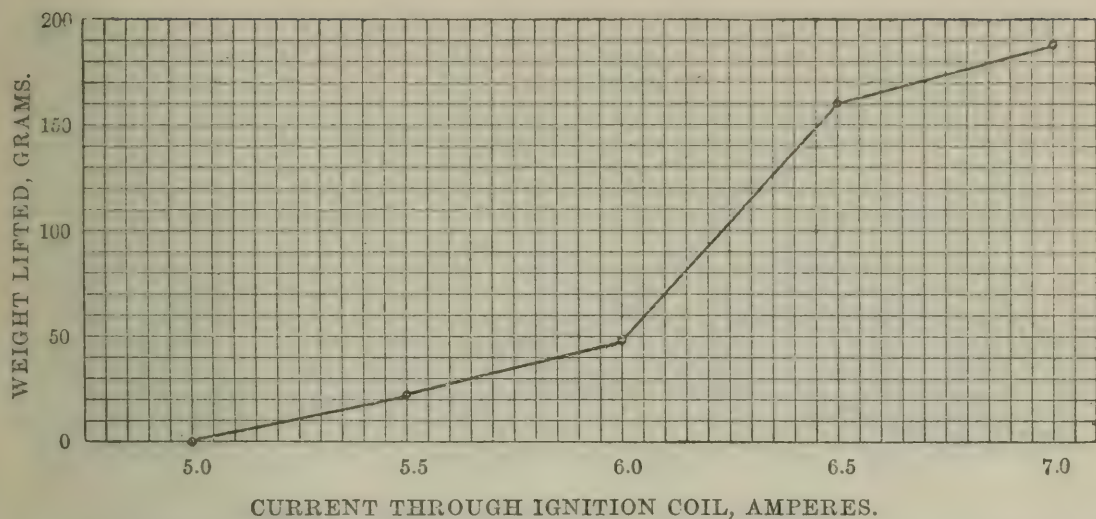


FIGURE 23.—Relative inflammability of coal No. 11156, Marion County, W. Va. Moisture, 1.22 per cent; volatile matter, 36.39 per cent; fixed carbon, 53.58 per cent; ash, 8.81 per cent; sulphur, 2.06 per cent.

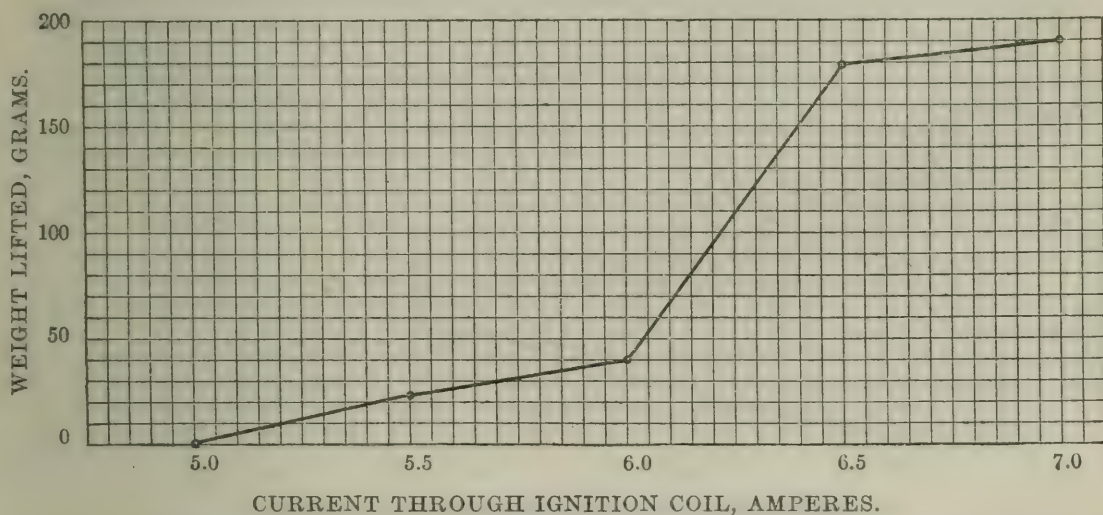


FIGURE 24.—Relative inflammability of coal No. 12029, Las Animas County, Colo. Moisture, 0.83 per cent; volatile matter, 32.77 per cent; fixed carbon, 49.09 per cent; ash, 17.31 per cent; sulphur, 0.94 per cent.

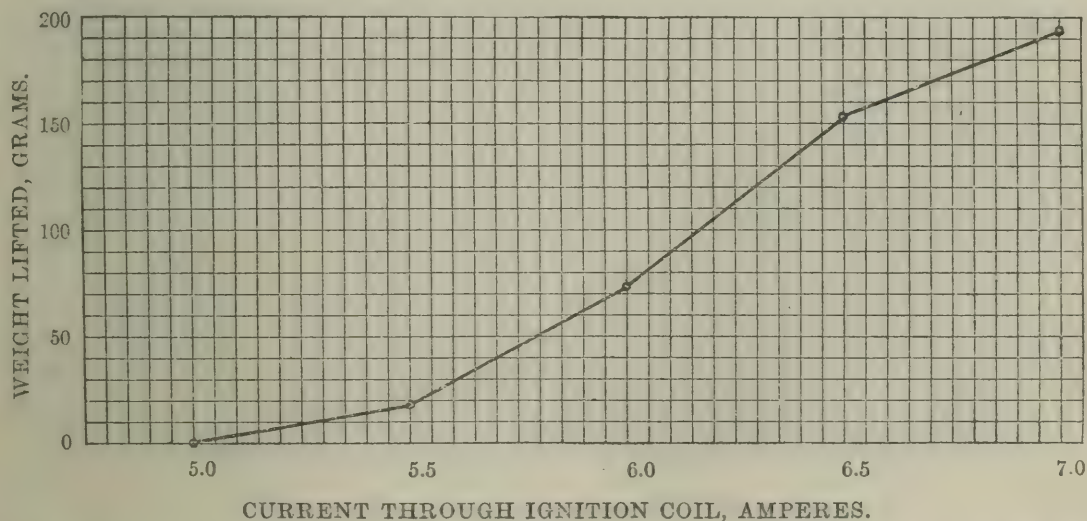


FIGURE 25.—Relative inflammability of coal No. 10741, El Paso County, Colo. Moisture, 11.31 per cent; volatile matter, 31.36 per cent; fixed carbon, 32.98 per cent; ash, 24.35 per cent; sulphur, 0.43 per cent.

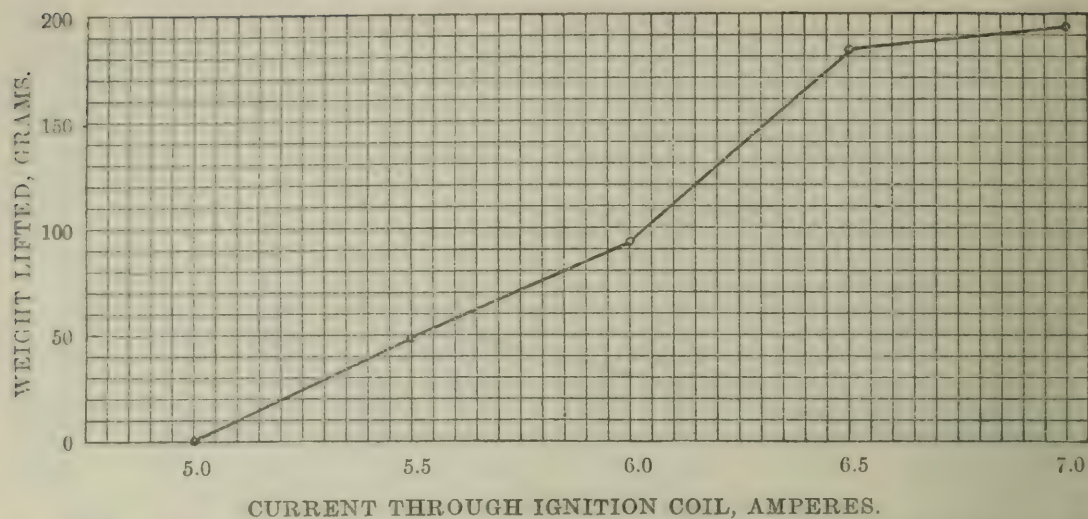


FIGURE 26.—Relative inflammability of coal No. 10713, Uinta County, Utah. Moisture, 7.75 per cent; volatile matter, 39.27 per cent; fixed carbon, 44.65 per cent; ash, 8.33 per cent; sulphur, 2.39 per cent.

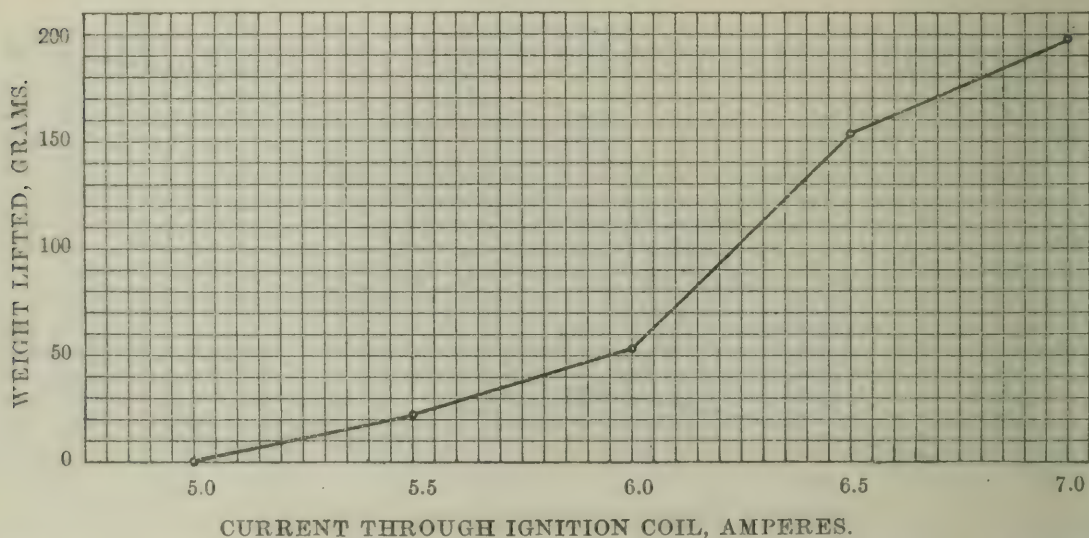


FIGURE 27.—Relative inflammability of coal No. 11433, Marion County, W. Va. Moisture, 1.47 per cent; volatile matter, 35.54 per cent; fixed carbon, 57.30 per cent; ash, 5.69 per cent; sulphur, 0.68 per cent.

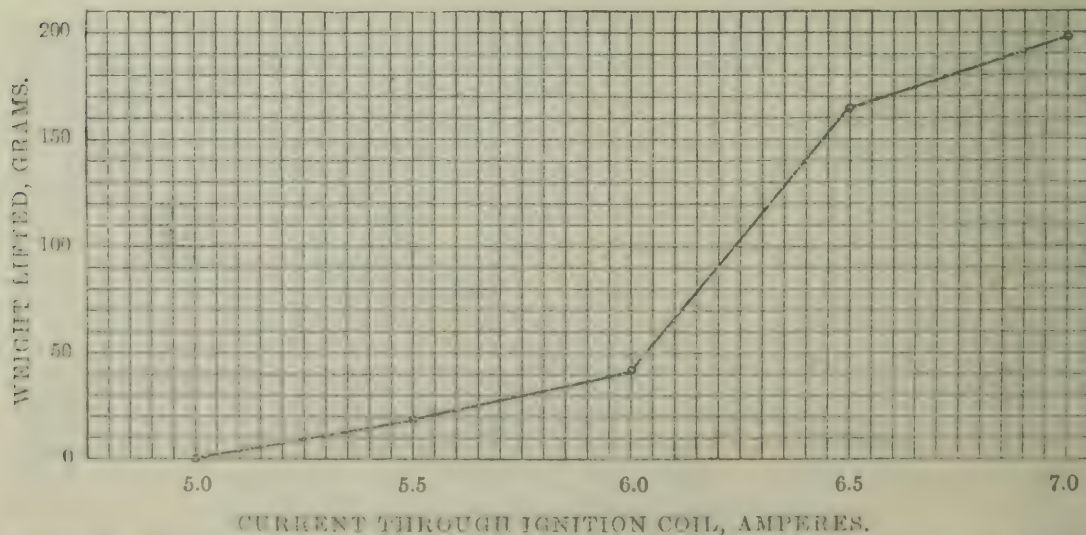


FIGURE 28.—Relative inflammability of coal No. 10916, Bledsoe County, Tenn. Moisture, 1.68 per cent; volatile matter, 29.92 per cent; fixed carbon, 61.91 per cent; ash, 6.49 per cent; sulphur, 0.53 per cent.

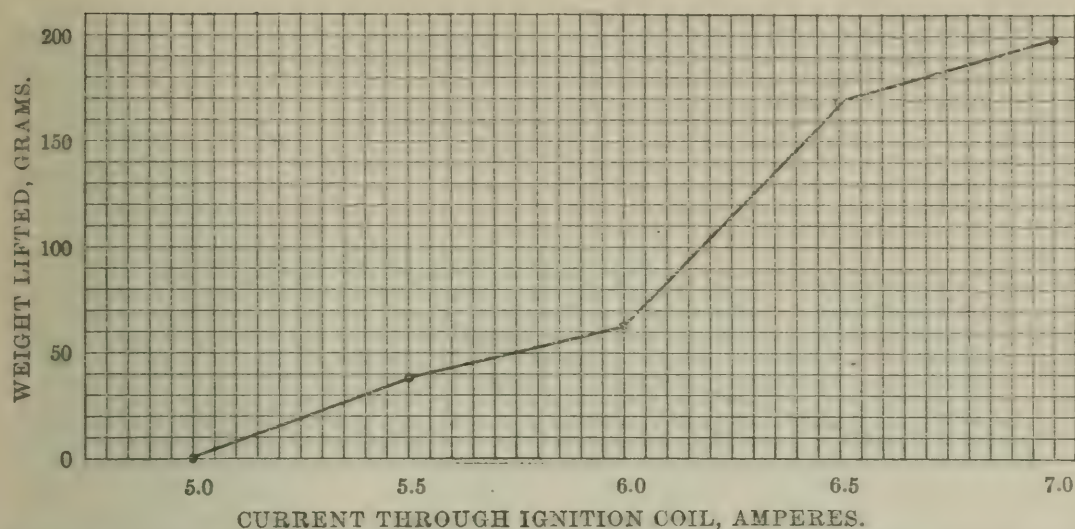


FIGURE 29.—Relative inflammability of coal No. 10959, Madison County, Ill. Moisture, 7.52 per cent; volatile matter, 33.52 per cent; fixed carbon, 43.93 per cent; ash, 10.03 per cent; sulphur, 3.89 per cent.

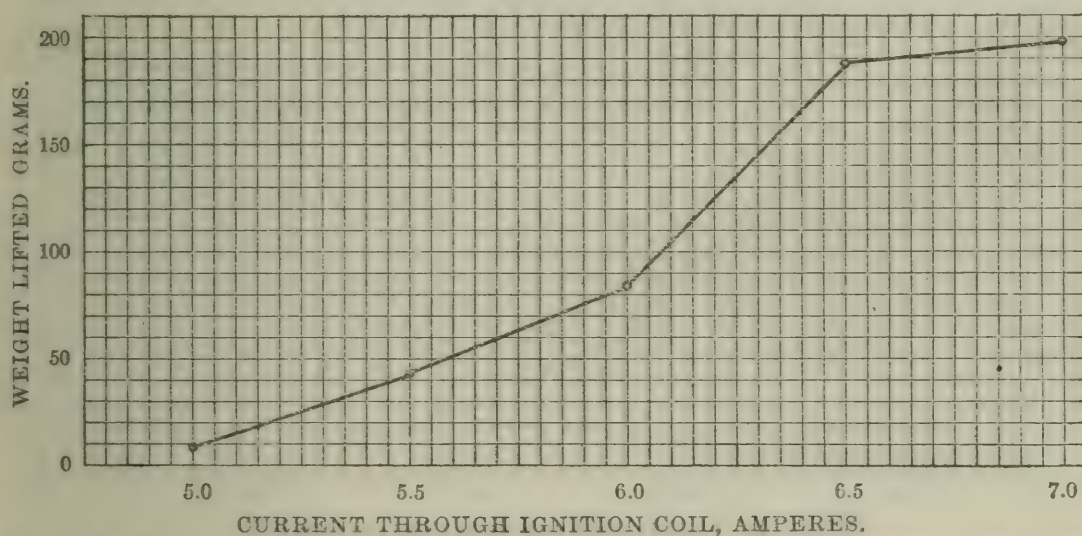


FIGURE 30.—Relative inflammability of coal No. 11006, Valley County, Mont. Moisture, 9.36 per cent; volatile matter, 41.40 per cent; fixed carbon, 40.59 per cent; ash, 8.65 per cent; sulphur, 0.62 per cent.

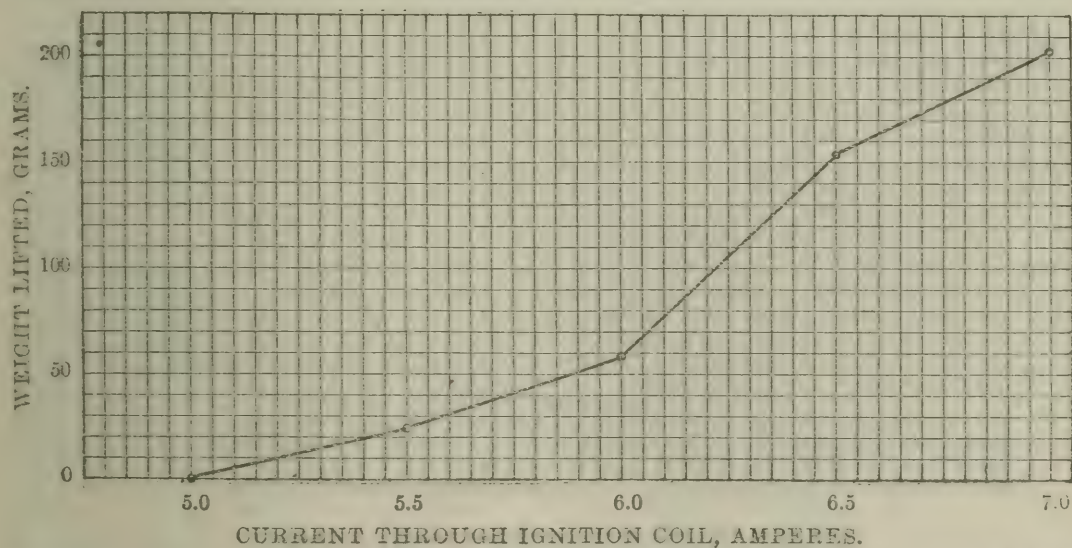


FIGURE 31.—Relative inflammability of coal No. 11382, Matanuska coal fields, Alaska. Moisture, 4.76 per cent; volatile matter, 33.00 per cent; fixed carbon, 53.85 per cent; ash, 5.39 per cent; sulphur, 0.24 per cent.

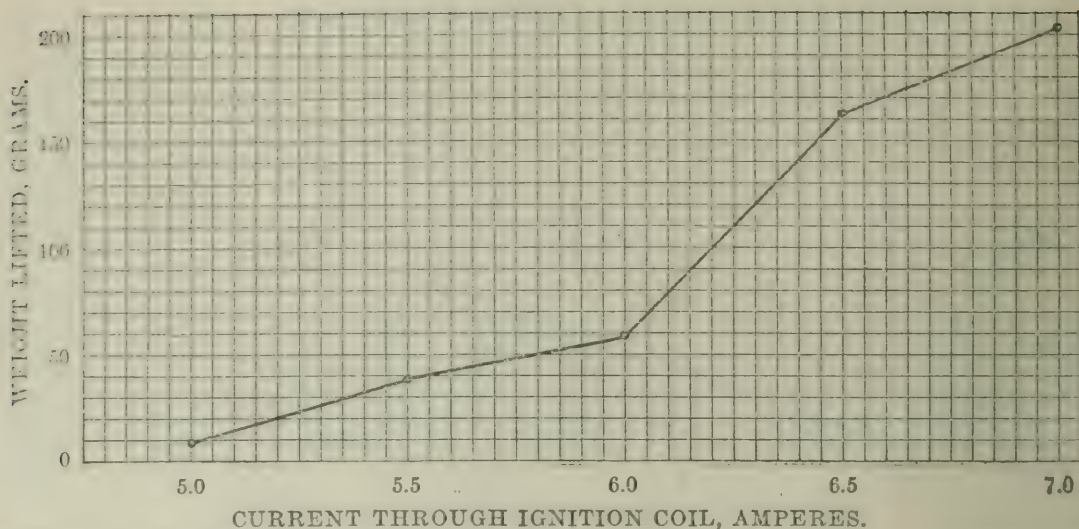


FIGURE 32.—Relative inflammability of coal No. 10997, Wasatch County, Utah. Moisture, 10.37 per cent; volatile matter, 39.68 per cent; fixed carbon, 46.75 per cent; ash, 3.20 per cent; sulphur, 0.74 per cent.

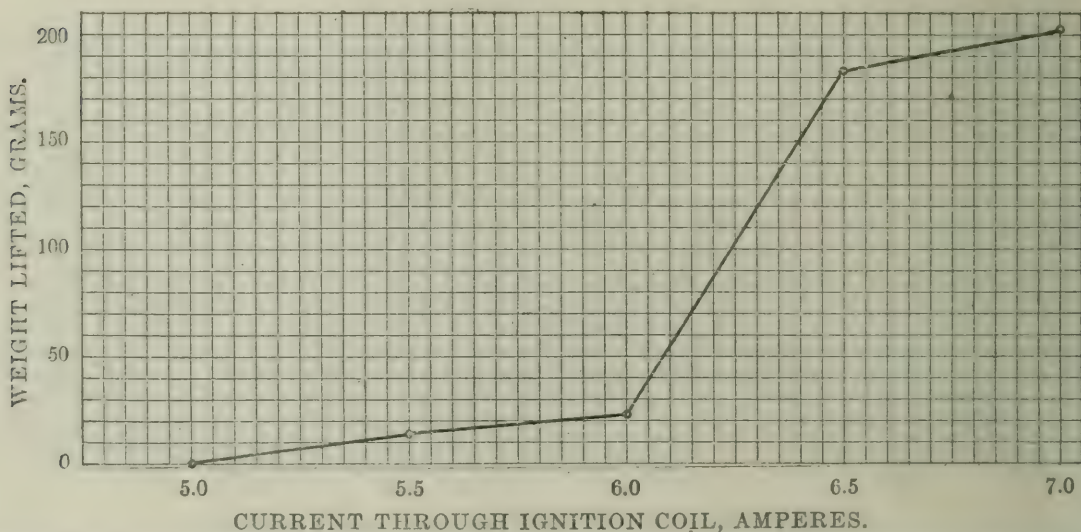


FIGURE 33.—Relative inflammability of coal No. 11592, Pittsburg County, Okla. Moisture, 1.52 per cent; volatile matter, 33.28 per cent; fixed carbon, 58.04 per cent; ash, 7.16 per cent; sulphur, 0.50 per cent.

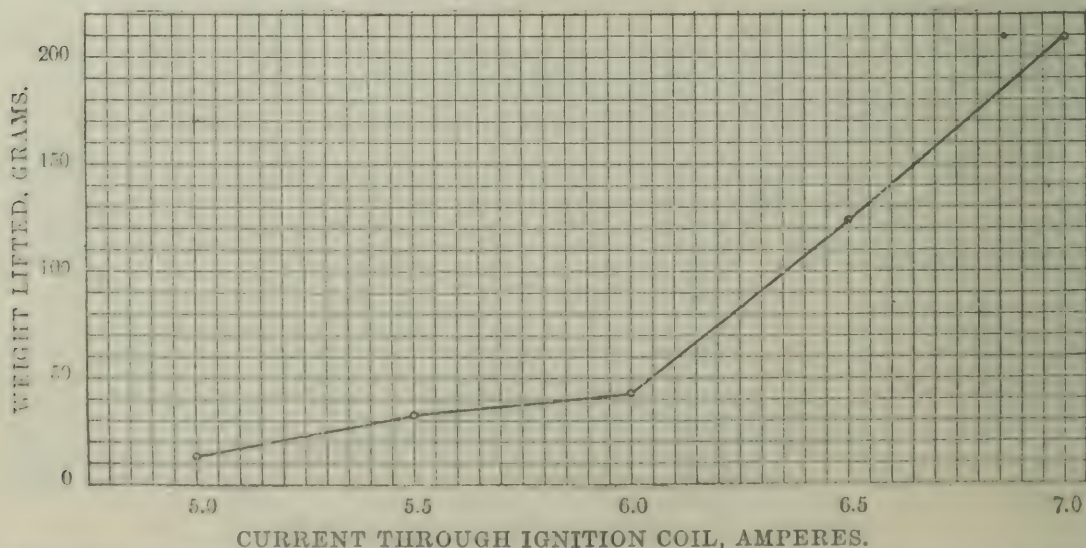


FIGURE 34.—Relative inflammability of coal No. 12025, Las Animas County, Colo. Moisture, 0.77 per cent; volatile matter, 31.58 per cent; fixed carbon, 57.57 per cent; ash, 10.03 per cent; sulphur, 0.60 per cent.

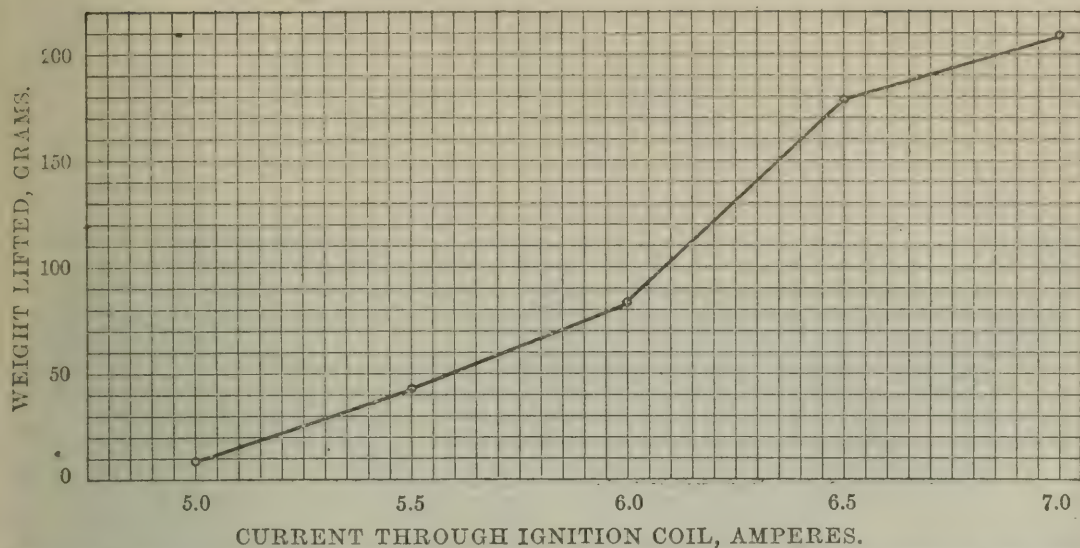


FIGURE 35.—Relative inflammability of coal No. 10575, Pierce County, Wash. Moisture, 1.68 per cent; volatile matter, 35.24 per cent; fixed carbon, 48.62 per cent; ash, 15.66 per cent; sulphur, 0.35 per cent.

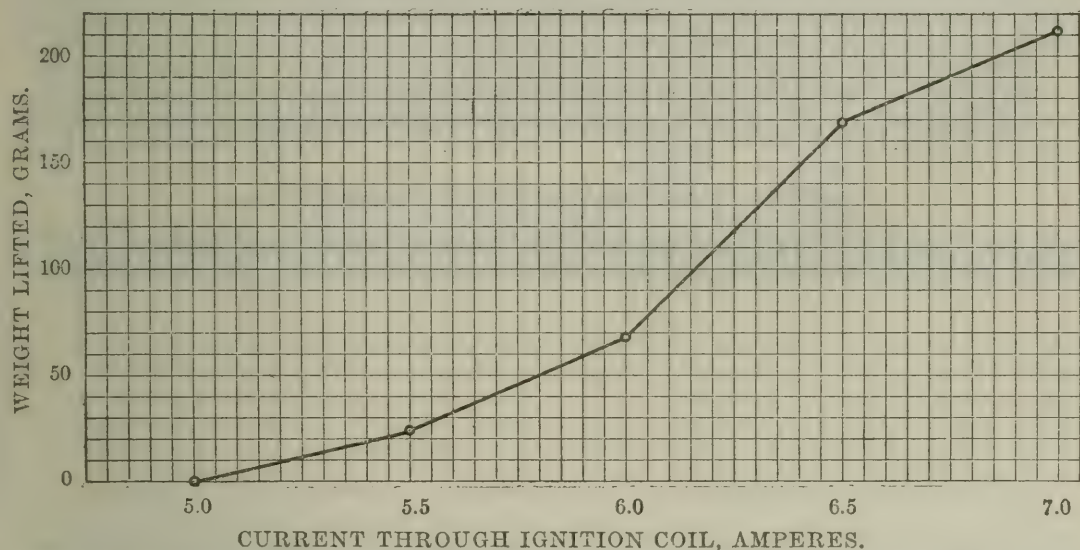


FIGURE 36.—Relative inflammability of coal No. 11465, Sweetwater County, Wyo. Moisture, 4.64 per cent; volatile matter, 39.96 per cent; fixed carbon, 51.76 per cent; ash, 3.64 per cent; sulphur, 1.07 per cent.

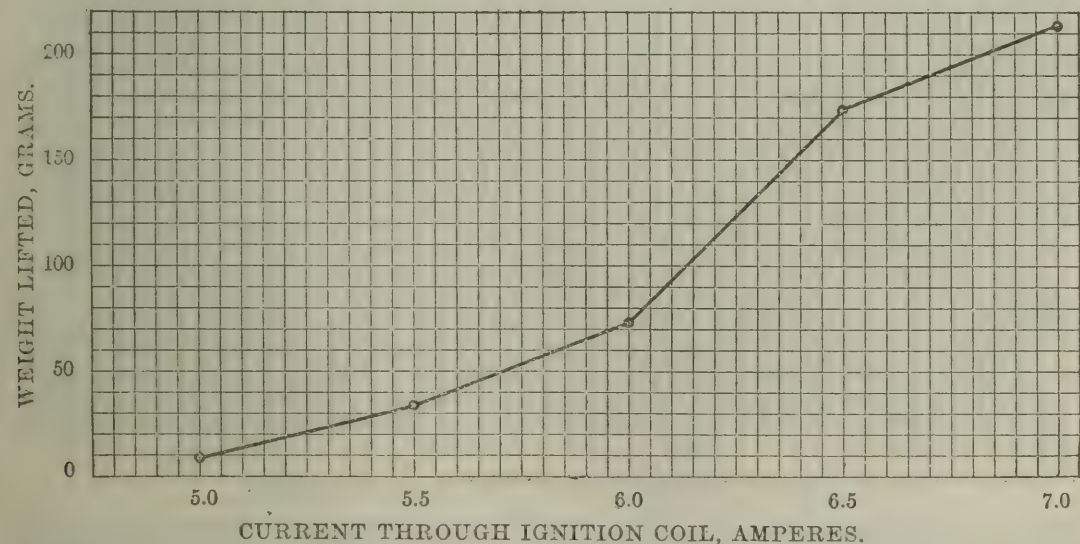


FIGURE 37.—Relative inflammability of coal No. 10556, Allegheny County, Pa. Moisture, 1.90 per cent; volatile matter, 35.59 per cent; fixed carbon, 57.87 per cent; ash, 4.64 per cent; sulphur, 0.52 per cent.

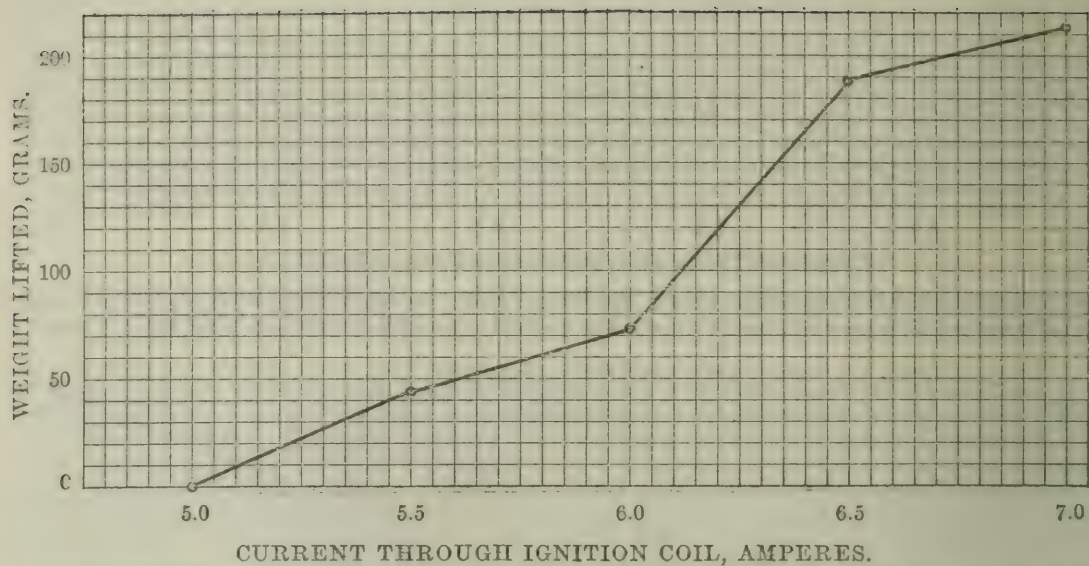


FIGURE 38.—Relative inflammability of coal No. 16961, Sullivan County, Ind. Moisture, 7.37 per cent; volatile matter, 34.81 per cent; fixed carbon, 51.79 per cent; ash, 6.03 per cent; sulphur, 1.17 per cent.

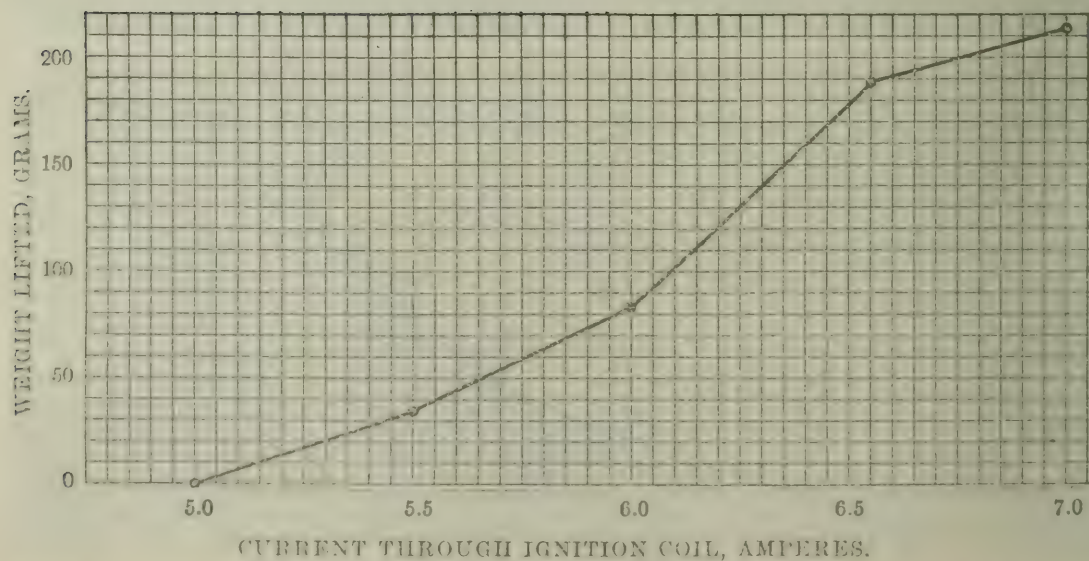


FIGURE 39.—Relative inflammability of coal No. 11354, Montgomery County, Ill. Moisture, 6.48 per cent; volatile matter, 36.27 per cent; fixed carbon, 44.60 per cent; ash, 12.65 per cent; sulphur, 4.03 per cent.

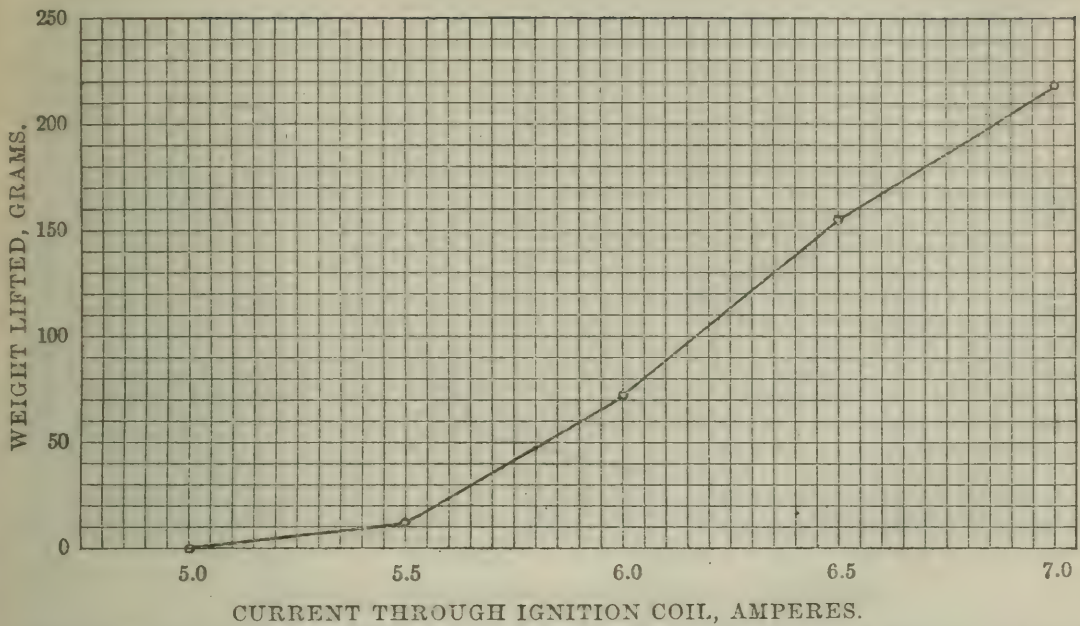


FIGURE 40.—Relative inflammability of coal No. 11184, Crawford County, Kans. Moisture, 1.50 per cent; volatile matter, 34.71 per cent; fixed carbon, 54.37 per cent; ash, 9.42 per cent; sulphur, 5.12 per cent.

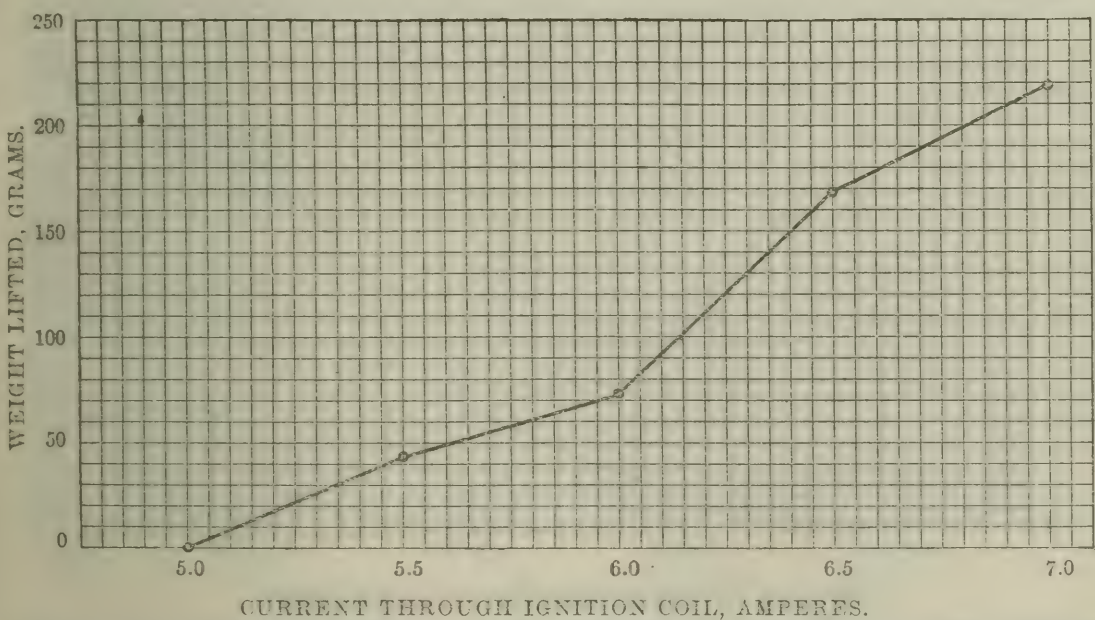


FIGURE 41.—Relative inflammability of coal No. 11130, Allegheny County, Pa. Moisture, 1.51 per cent; volatile matter, 35.22 per cent; fixed carbon, 56.67 per cent; ash, 6.60 per cent; sulphur, 0.97 per cent.

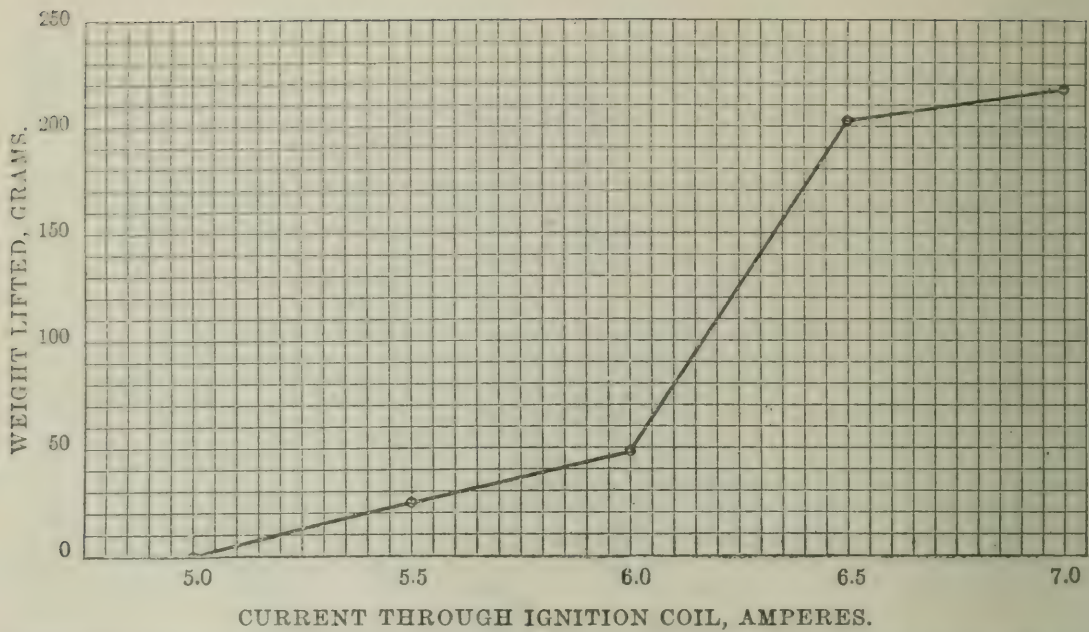


FIGURE 42.—Relative inflammability of coal No. 11180, Barton County, Mo. Moisture, 1.28 per cent; volatile matter, 33.47 per cent; fixed carbon, 55.91 per cent; ash, 9.34 per cent; sulphur, 3.78 per cent.

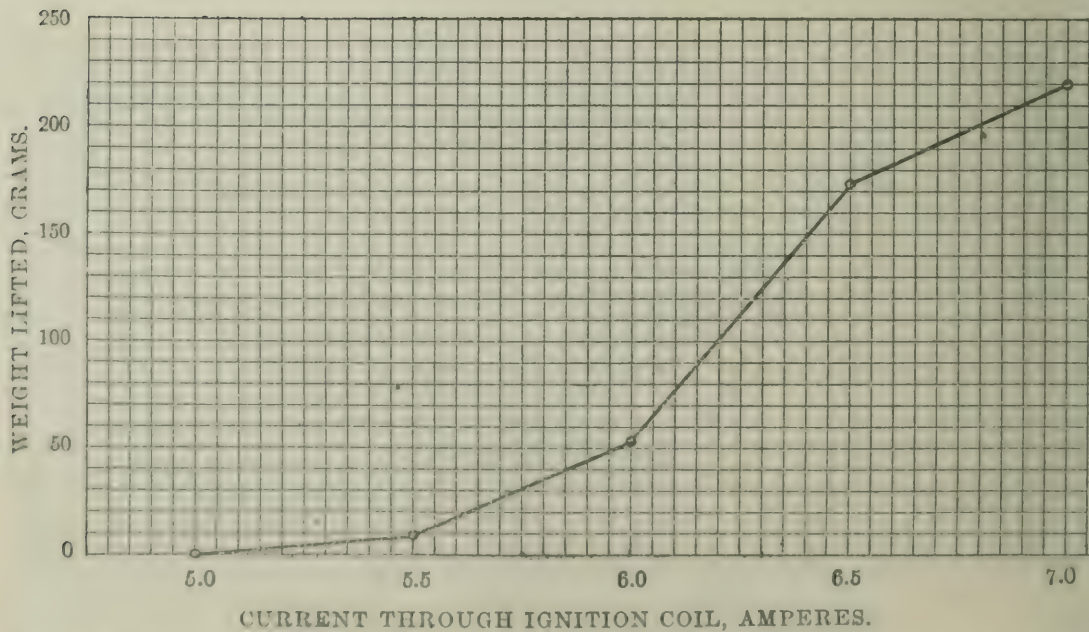


FIGURE 43.—Relative inflammability of coal No. 11188, Barton County, Mo. Moisture, 1.64 per cent; volatile matter, 32.37 per cent; fixed carbon, 53.99 per cent; ash, 12.00 per cent; sulphur, 5.22 per cent.

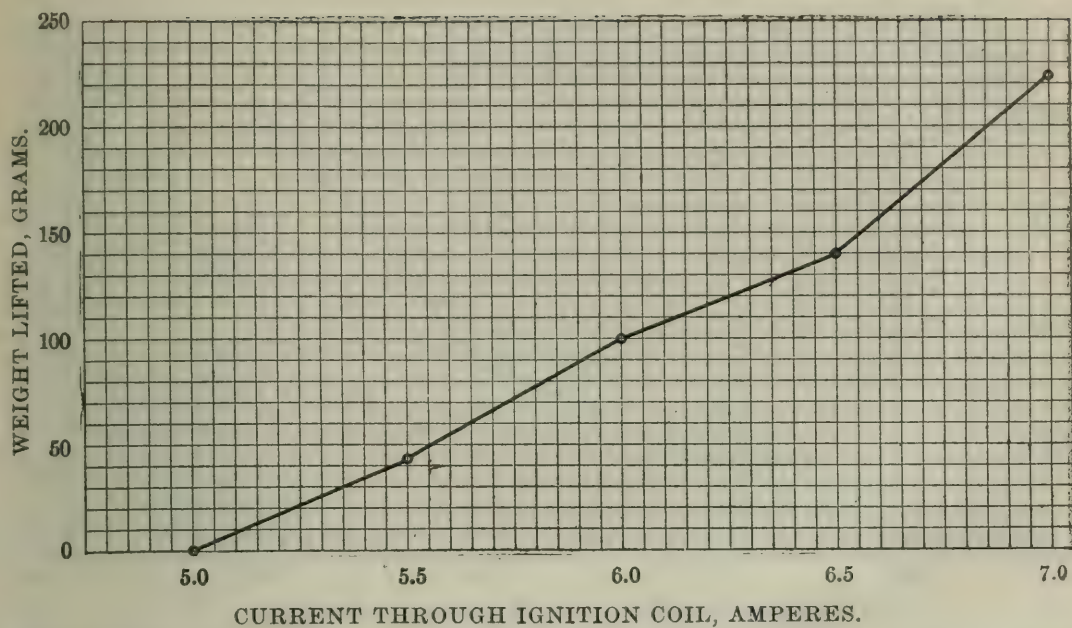


FIGURE 44.—Relative inflammability of coal No. 12028, Las Animas County, Colo. Moisture, 1.27 per cent; volatile matter, 33.18 per cent; fixed carbon, 56.16 per cent; ash, 9.39 per cent; sulphur, 0.63 per cent.

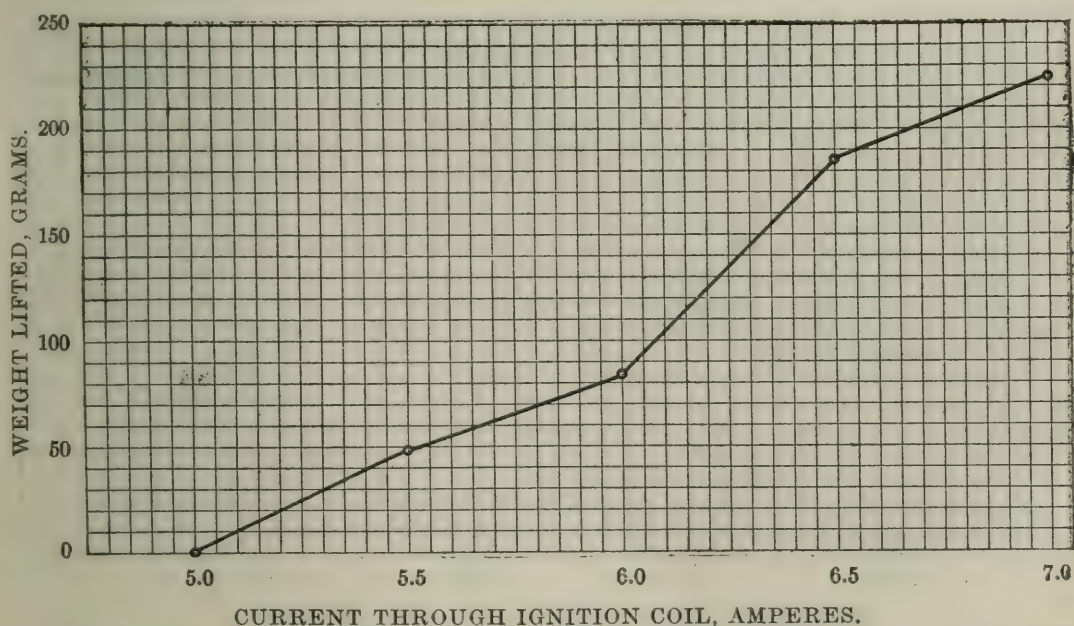


FIGURE 45.—Relative inflammability of coal No. 10960, Sullivan County, Ind. Moisture, 7.20 per cent; volatile matter, 36.61 per cent; fixed carbon, 50.81 per cent; ash, 5.38 per cent; sulphur, 0.88 per cent.

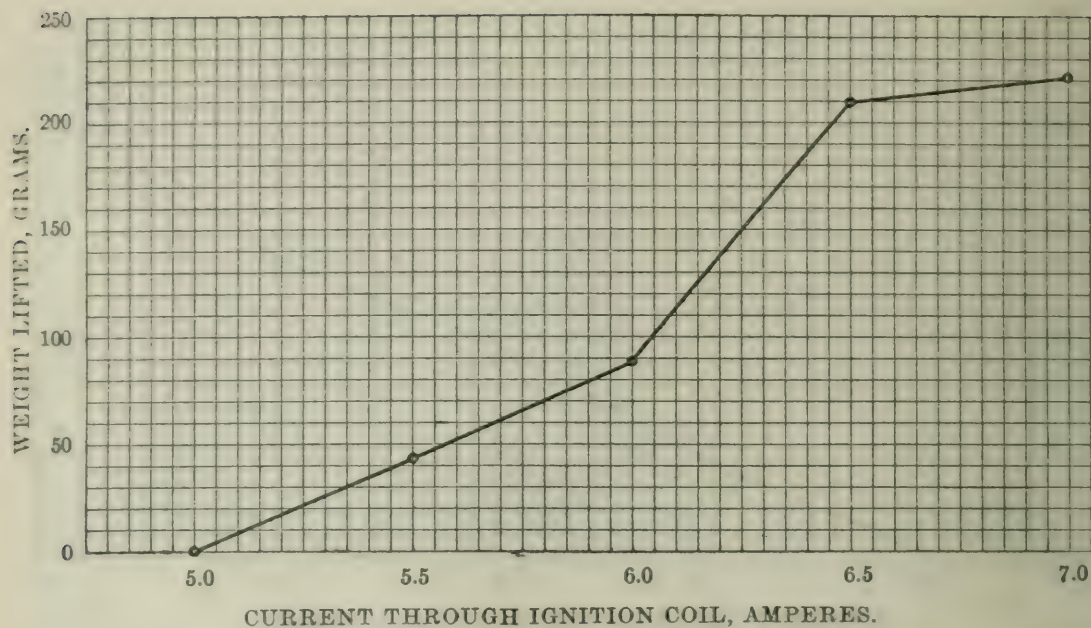


FIGURE 46.—Relative inflammability of coal No. 12004, Pike County, Ky. Moisture, 1.45 per cent; volatile matter, 35.66 per cent; fixed carbon, 60.18 per cent; ash, 2.71 per cent; sulphur, 0.57 per cent.

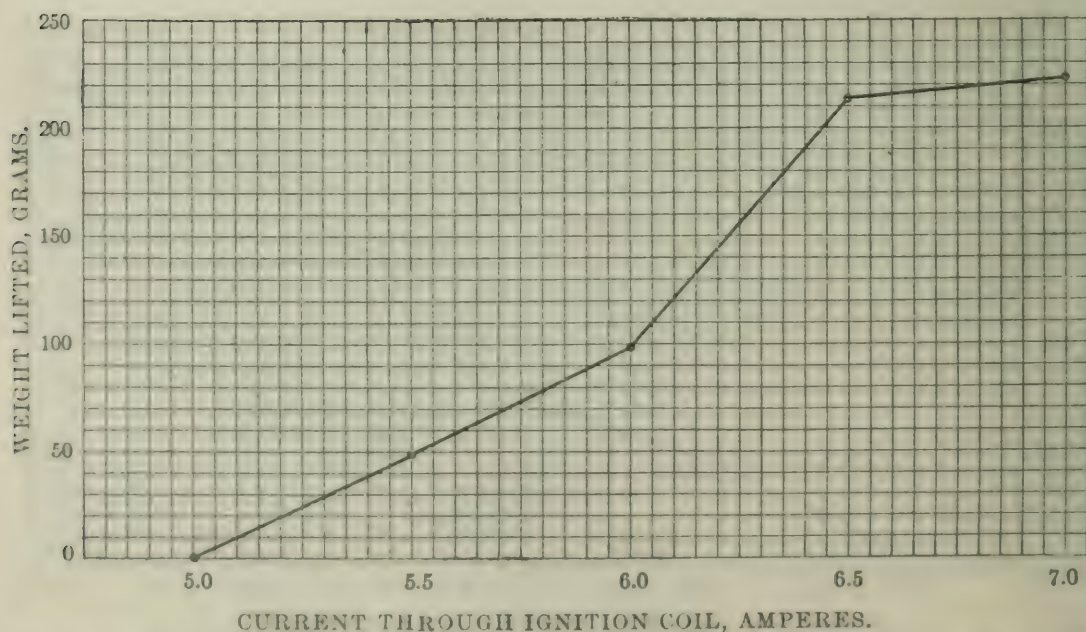


FIGURE 47.—Relative inflammability of coal No. 11984, Allegheny County, Pa. Moisture, 1.70 per cent; volatile matter, 35.73 per cent; fixed carbon, 56.32 per cent; ash, 6.25 per cent; sulphur, 1.49 per cent.

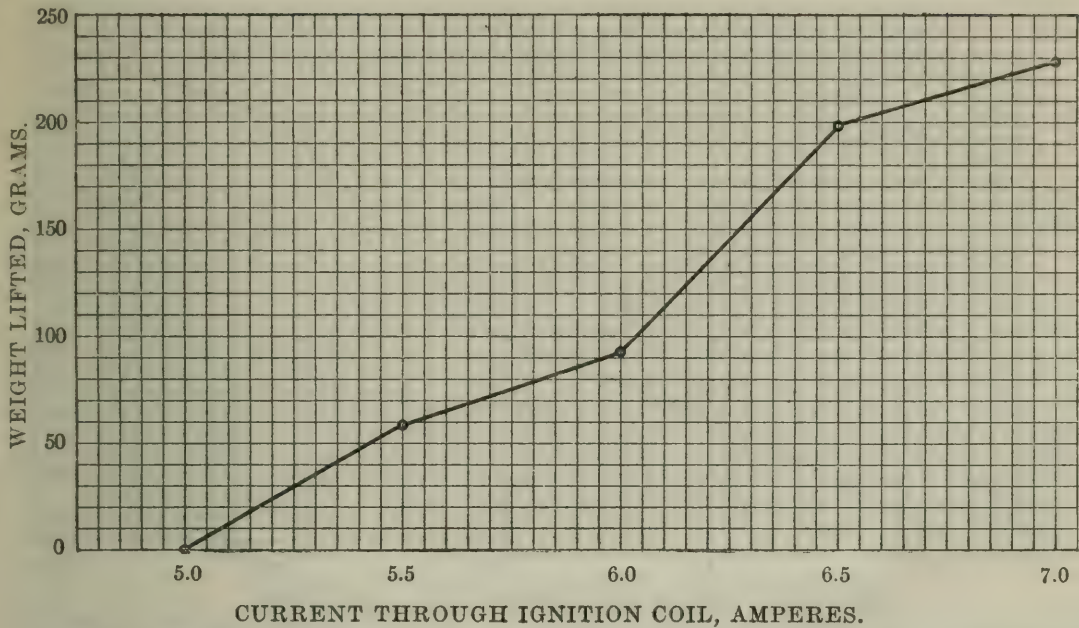


FIGURE 48.—Relative inflammability of coal No. 10739, Russell County, Va. Moisture, 0.78 per cent; volatile matter, 36.37 per cent; fixed carbon, 57.45 per cent; ash, 5.40 per cent; sulphur, 0.58 per cent.

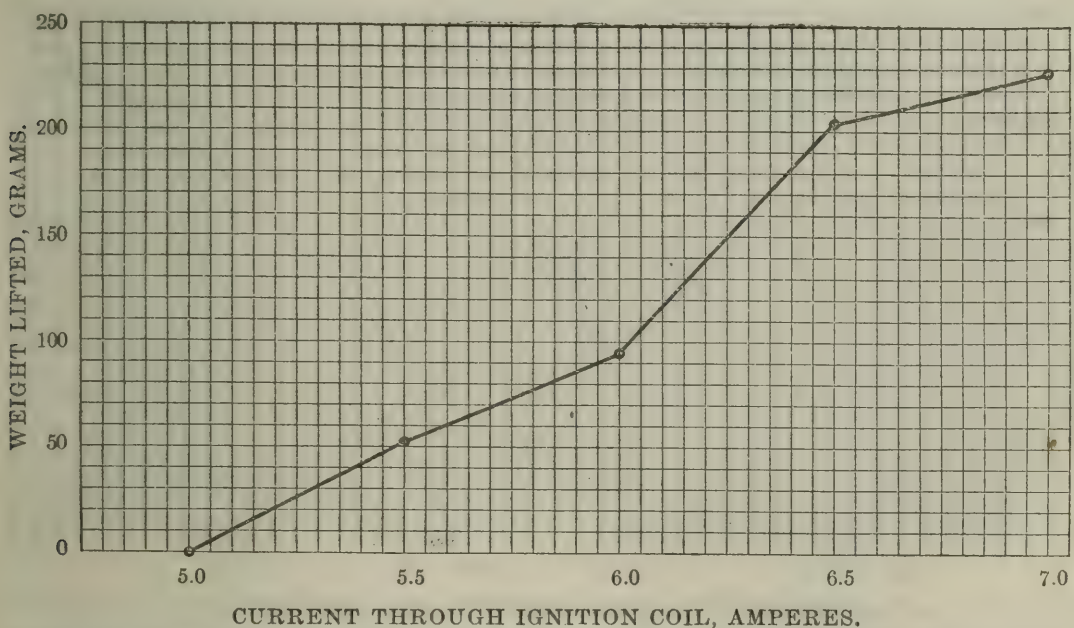


FIGURE 49.—Relative inflammability of coal No. 10736, Russell County, Va. Moisture, 0.98 per cent; volatile matter, 35.60 per cent; fixed carbon, 57.54 per cent; ash, 5.88 per cent; sulphur, 0.60 per cent.

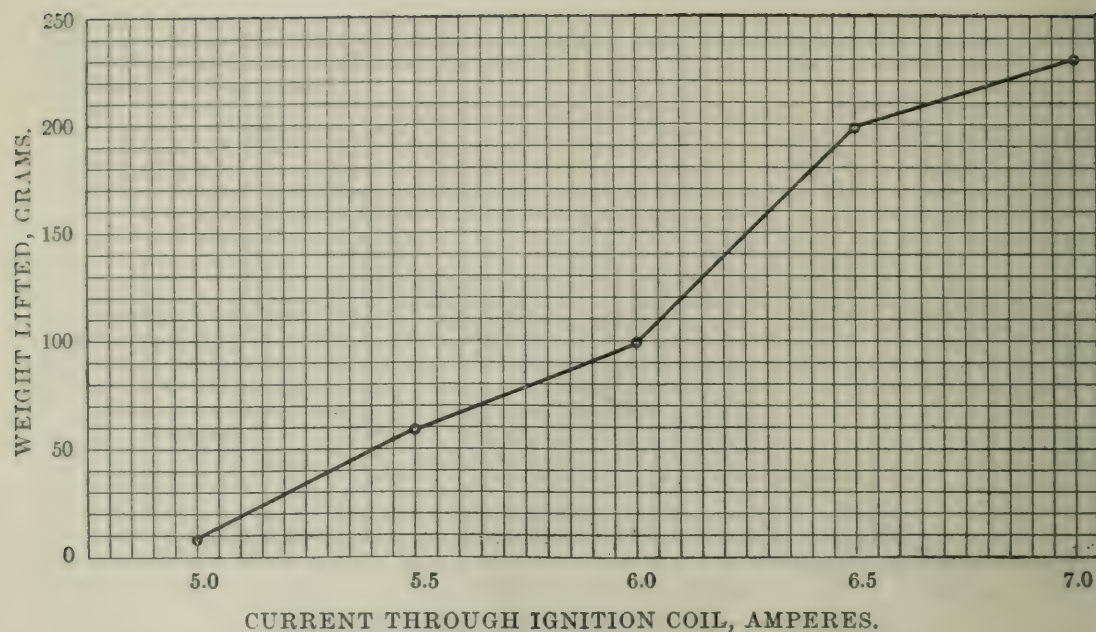


FIGURE 50.—Relative inflammability of coal No. 10845, Allegheny County, Pa. Moisture, 1.81 per cent; volatile matter, 35.76 per cent; fixed carbon, 56.41 per cent; ash, 6.02 per cent; sulphur, 1.20 per cent.

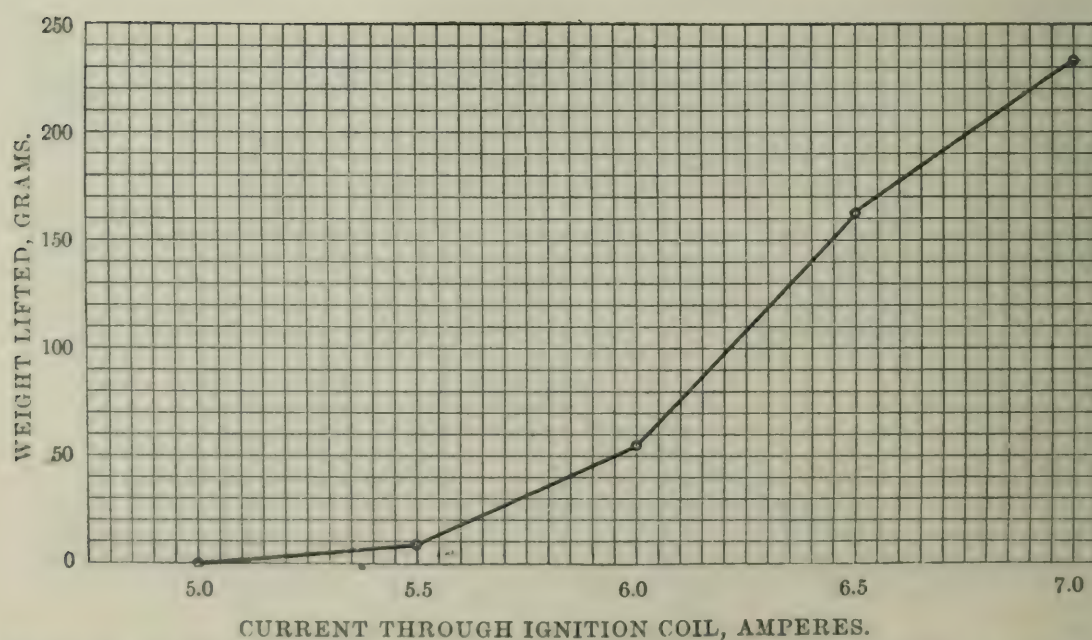


FIGURE 51.—Relative inflammability of coal No. 11569, Pittsburg County, Okla. Moisture, 1.41 per cent; volatile matter, 31.44 per cent; fixed carbon, 58.87 per cent; ash, 5.28 per cent; sulphur, 0.55 per cent.

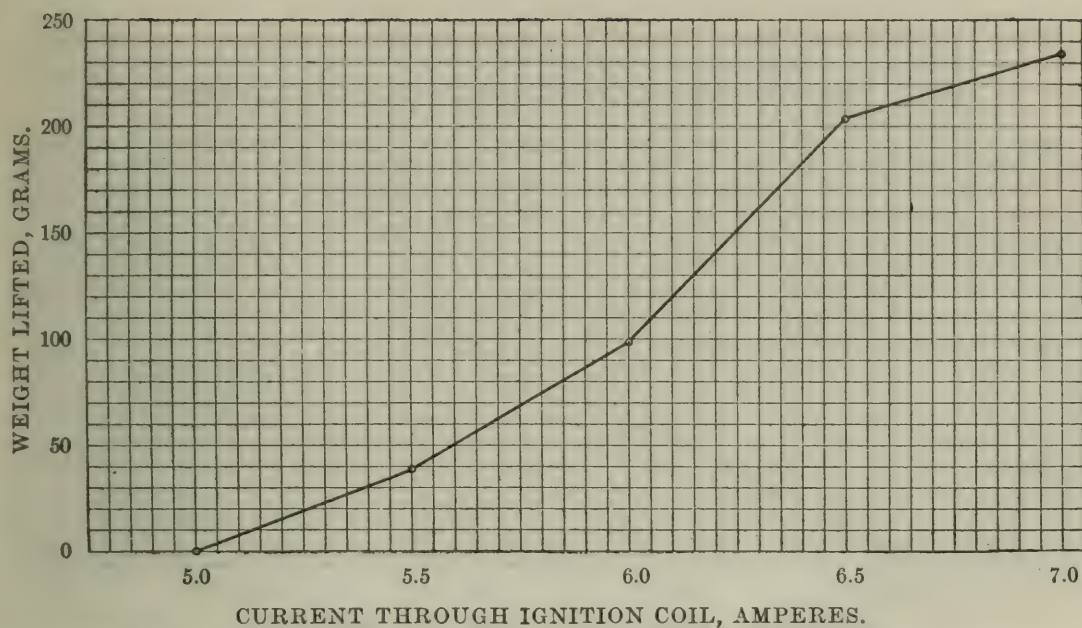


FIGURE 52.—Relative inflammability of coal No. 11460, Sweetwater County, Wyo. Moisture, 3.88 per cent; volatile matter, 39.55 per cent; fixed carbon, 52.81 per cent; ash, 3.76 per cent; sulphur, 1.11 per cent.

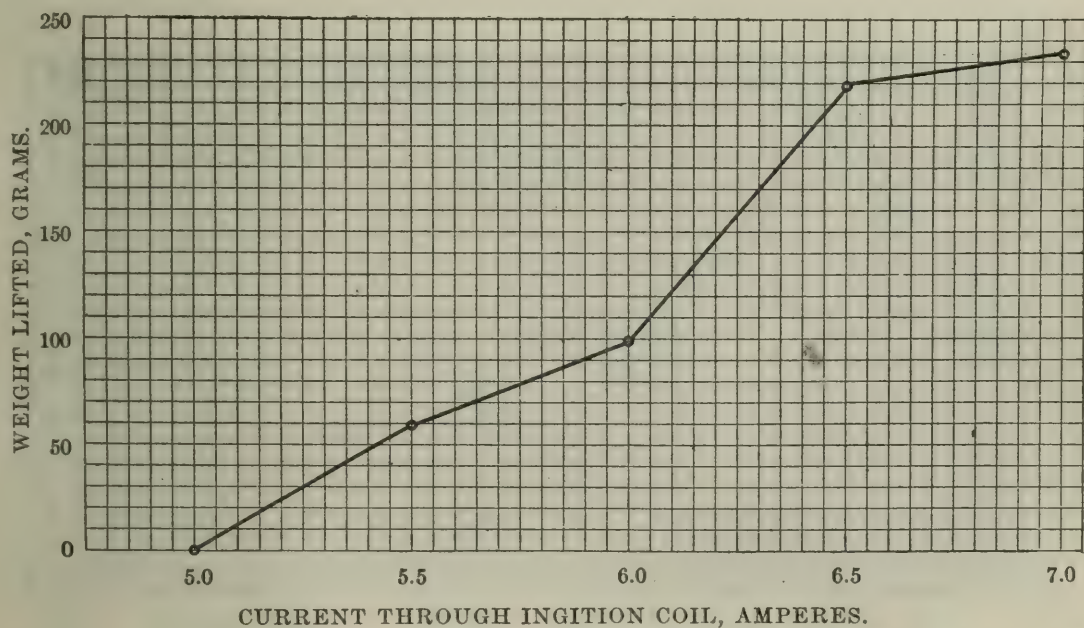


FIGURE 53.—Relative inflammability of coal No. 11985, Allegheny County, Pa. Moisture, 1.67 per cent; volatile matter, 35.85 per cent; fixed carbon, 55.73 per cent; ash, 6.75 per cent; sulphur, 1.51 per cent.

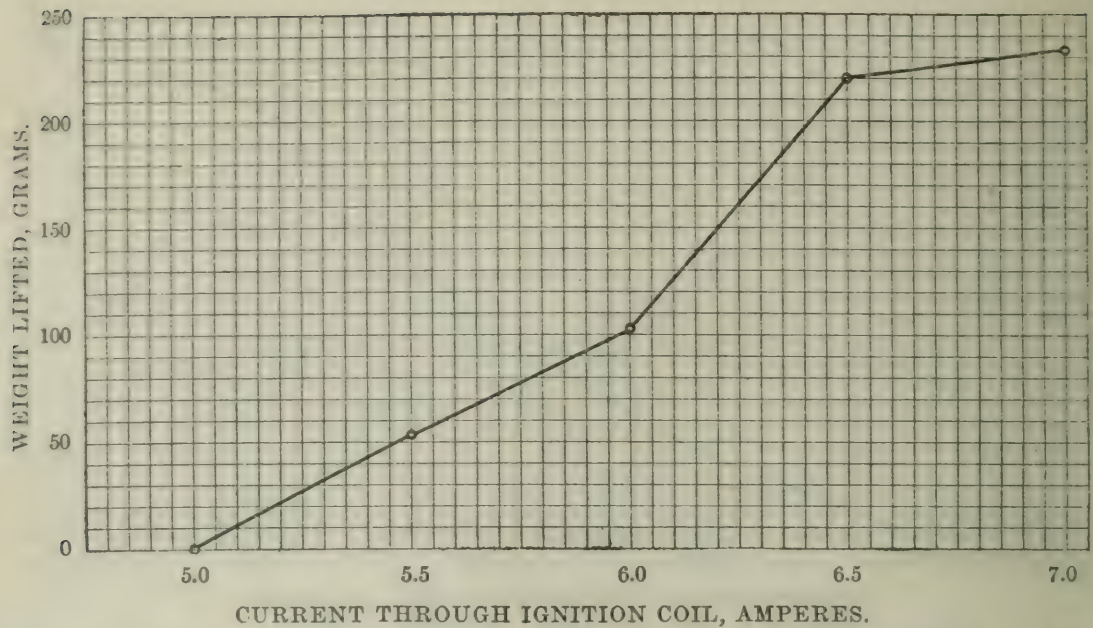


FIGURE 54.—Relative inflammability of coal No. 11983, Allegheny County, Pa. Moisture, 1.83 per cent; volatile matter, 35.62 per cent; fixed carbon, 56.69 per cent; ash, 5.86 per cent; sulphur, 1.19 per cent.

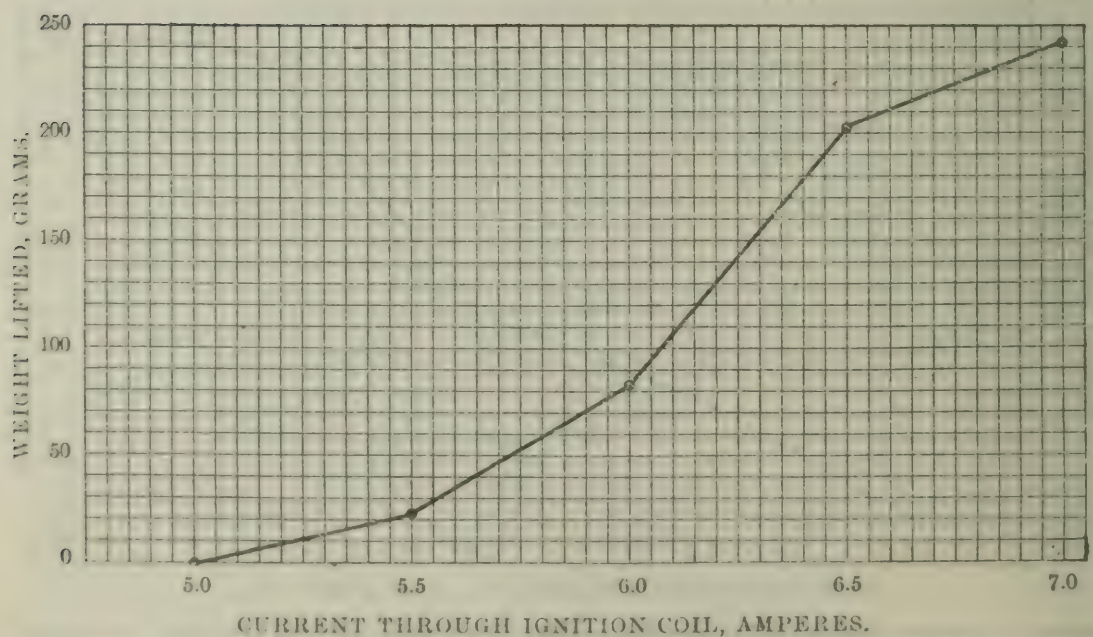


FIGURE 55.—Relative inflammability of coal No. 11919, Pittsburg County, Okla. Moisture, 1.89 per cent; volatile matter, 35.69 per cent; fixed carbon, 58.00 per cent; ash, 4.42 per cent; sulphur, 0.63 per cent.

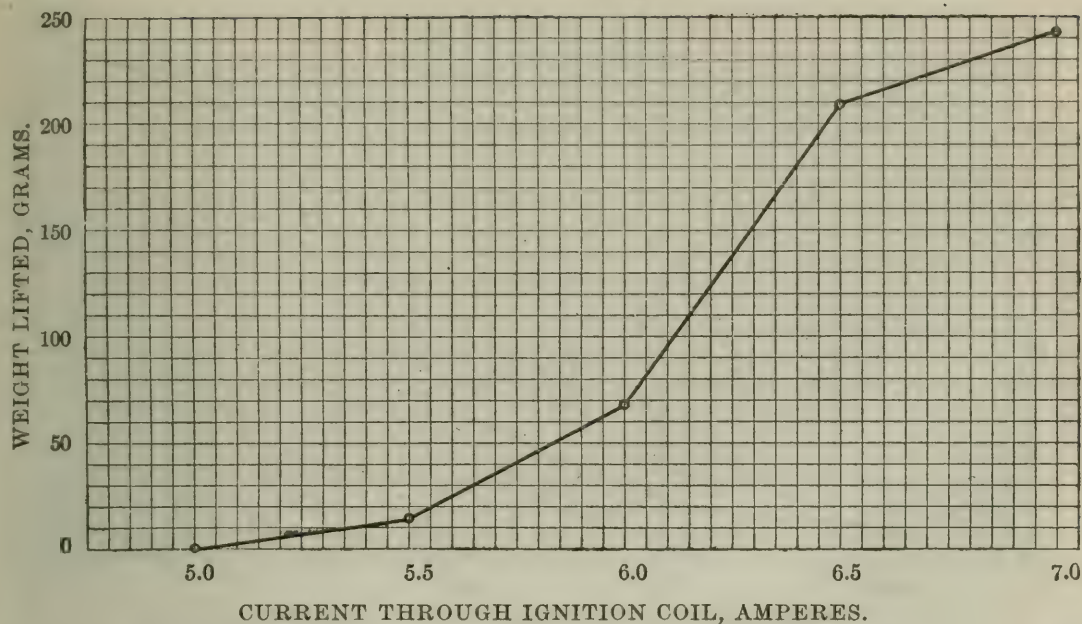


FIGURE 56.—Relative inflammability of coal No. 11594, Pittsburg County, Okla. Moisture, 1.60 per cent; volatile matter, 34.06 per cent; fixed carbon, 59.24 per cent; ash, 5.10 per cent; sulphur, 0.50 per cent.

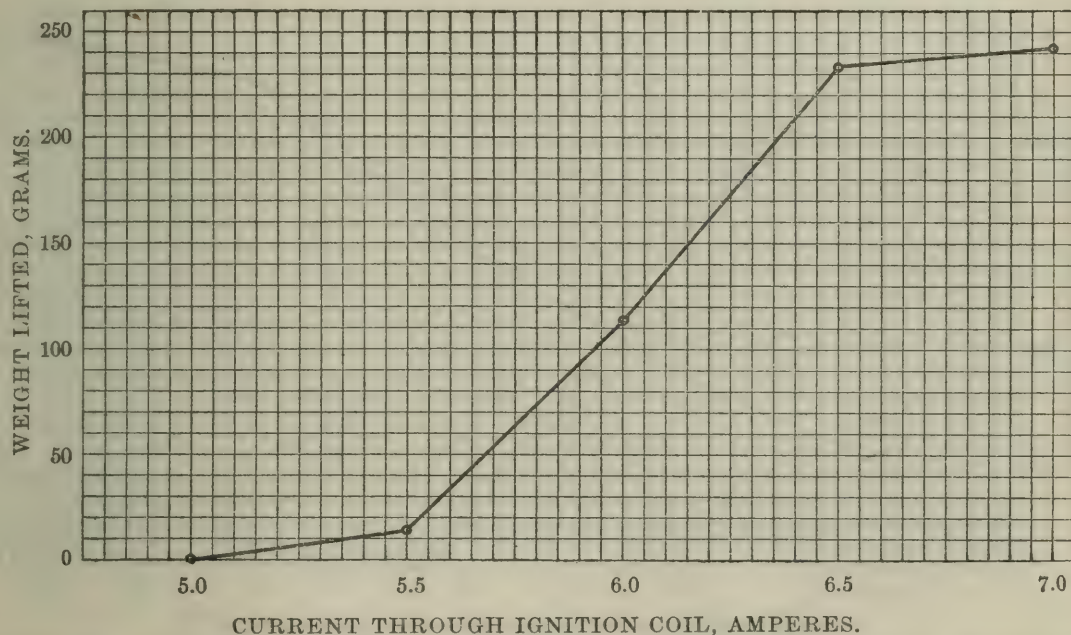


FIGURE 57.—Relative inflammability of coal No. 11058, Wasatch County, Utah. Moisture, 14.35 per cent; volatile matter, 39.24 per cent; fixed carbon, 39.83 per cent; ash, 6.58 per cent; sulphur, 0.73 per cent.

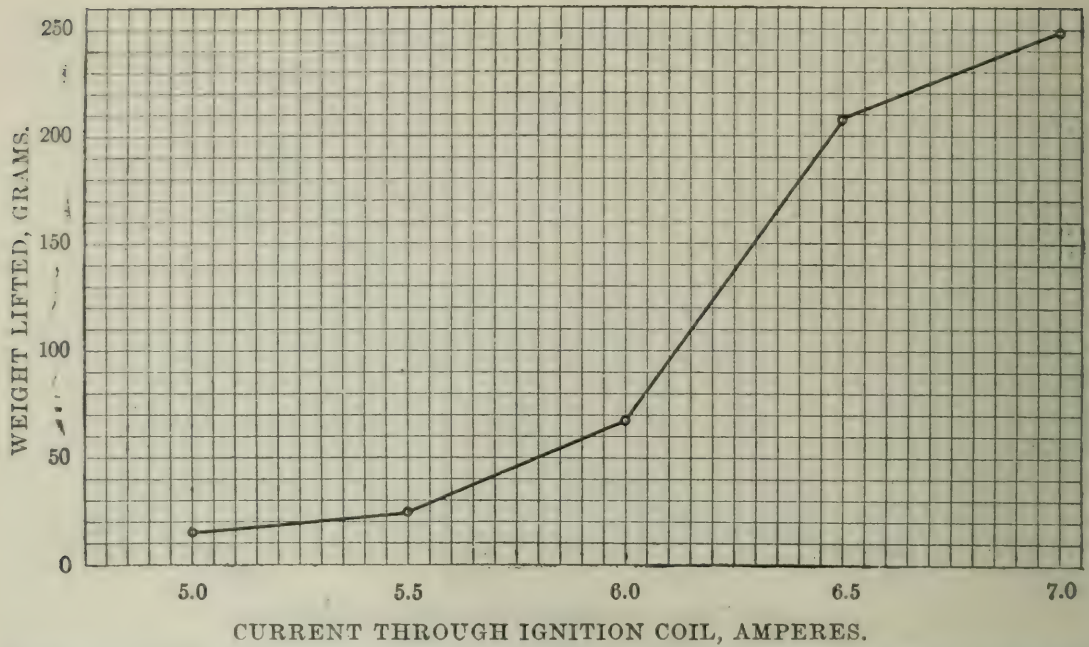


FIGURE 58.—Relative inflammability of coal No. 11930, Las Animas County, Colo. Moisture, 0.86 per cent; volatile matter, 31.07 per cent; fixed carbon, 57.39 per cent; ash, 10.68 per cent; sulphur, 0.62 per cent.

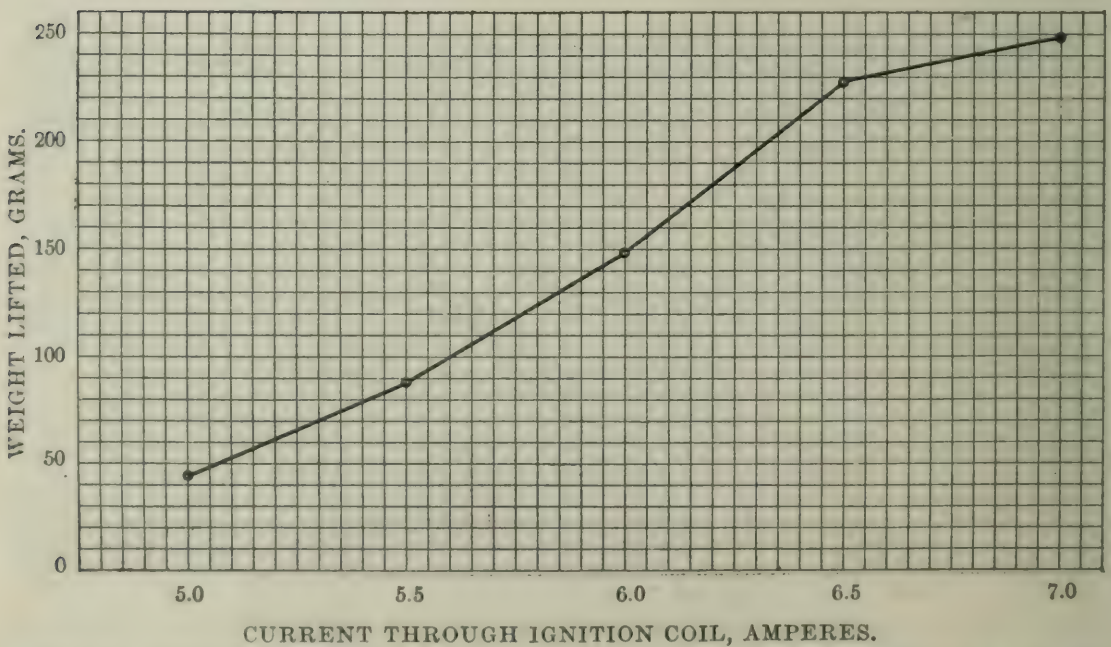


FIGURE 59.—Relative inflammability of coal No. 10189, Huerfano County, Colo. Moisture, 4.83 per cent; volatile matter, 37.81 per cent; fixed carbon, 49.61 per cent; ash, 7.75 per cent; sulphur, 0.57 per cent.

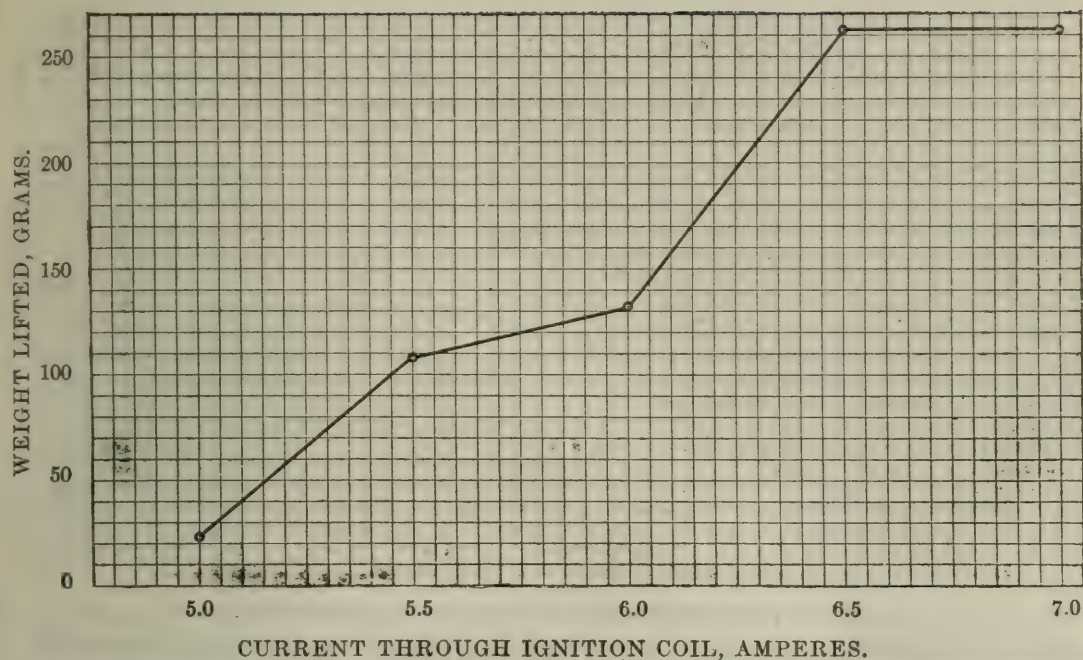


FIGURE 60.—Relative inflammability of coal No. 10909, Carbon County, Utah. Moisture, 3.33 per cent; volatile matter, 41.79 per cent; fixed carbon, 47.76 per cent; ash, 7.12 per cent; sulphur, 0.57 per cent.

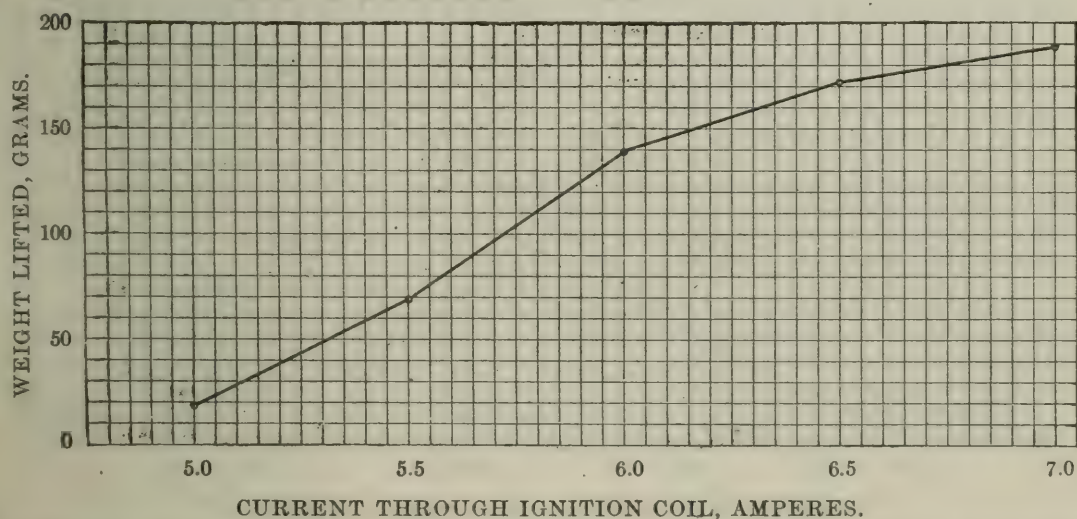


FIGURE 61.—Relative inflammability of coal No. 10671, Natrona County, Wyo. Moisture, 12.21 per cent; volatile matter, 34.22 per cent; fixed carbon, 46.89 per cent; ash, 6.68 per cent; sulphur, 0.59 per cent.

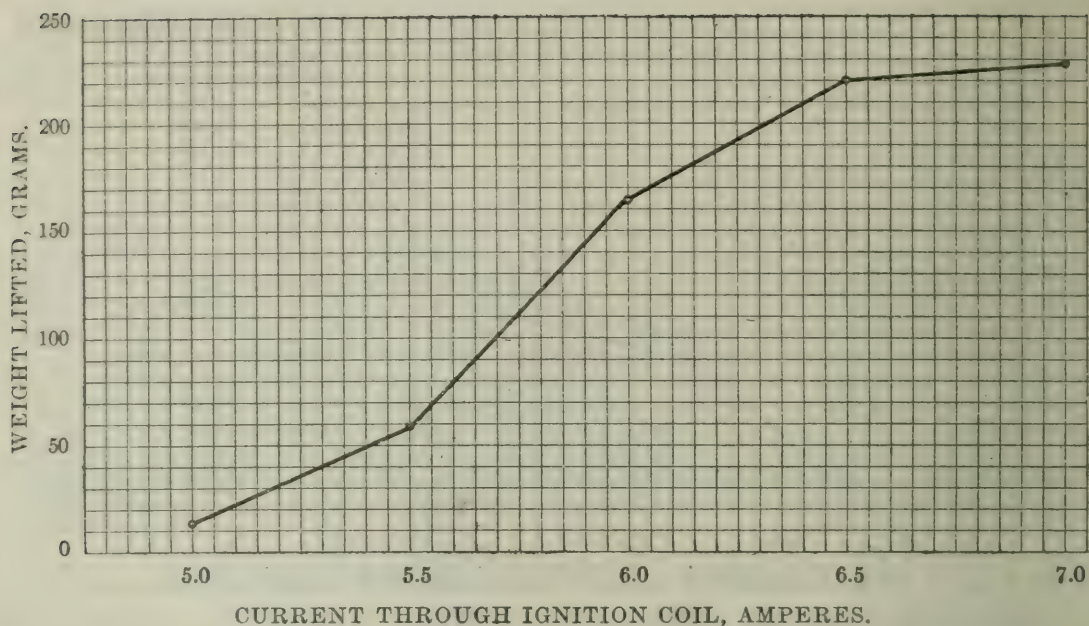


FIGURE 62.—Relative inflammability of coal No. 10899, Valley County, Mont. Moisture, 11.18 per cent; volatile matter, 38.82 per cent; fixed carbon, 42.70 per cent; ash, 7.30 per cent; sulphur, 0.54 per cent.

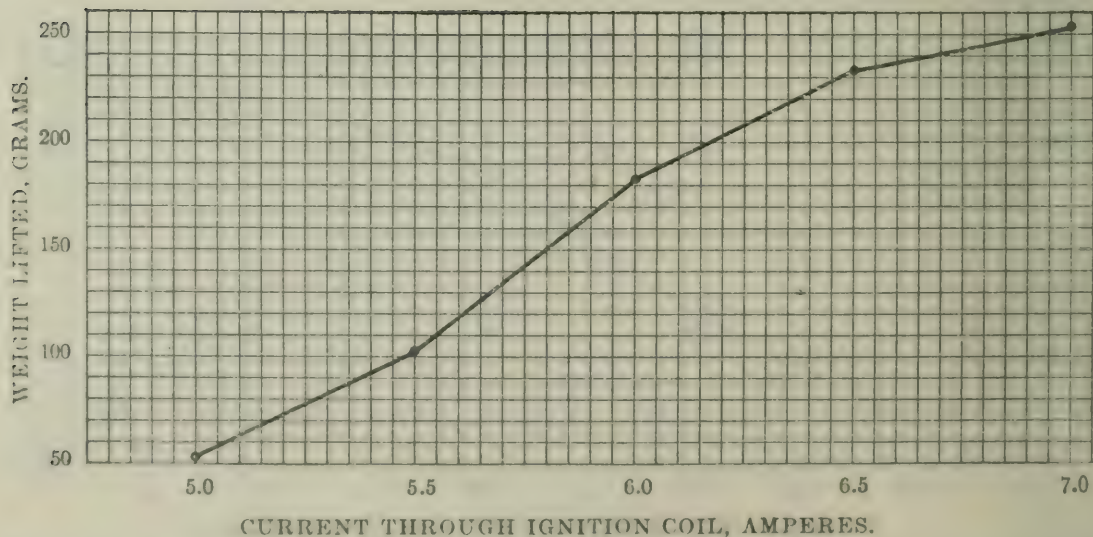


FIGURE 63.—Relative inflammability of coal No. 10998, Wasatch County, Utah. Moisture, 6.14 per cent; volatile matter, 42.29 per cent; fixed carbon, 45.04 per cent; ash, 6.53 per cent; sulphur, 0.90 per cent.

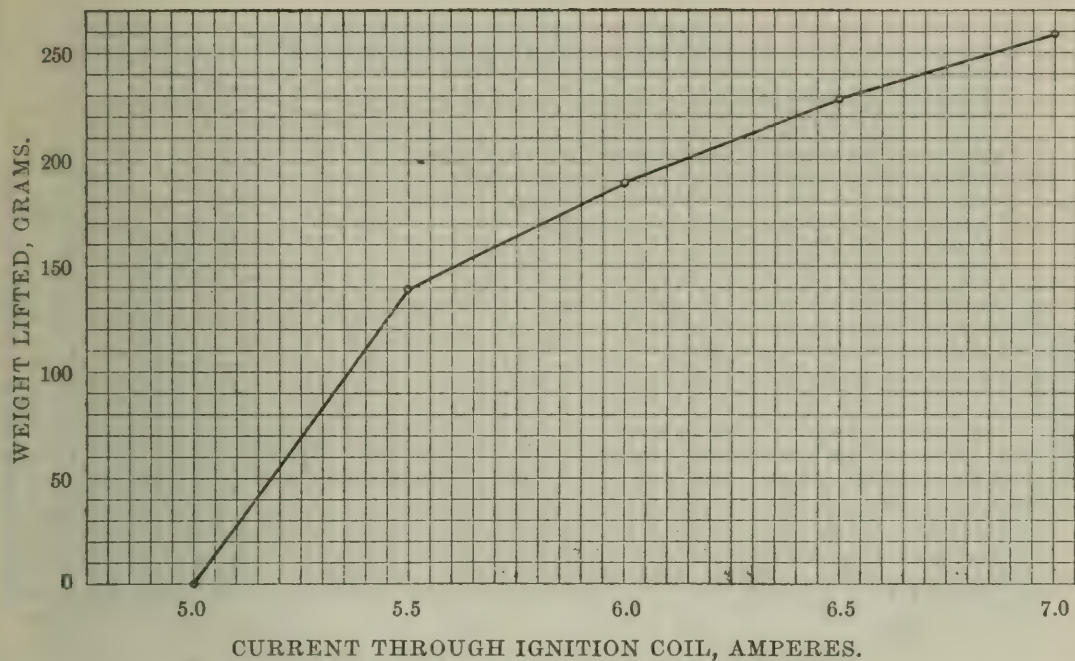


FIGURE 64.—Relative inflammability of coal No. 10810, Sheridan County, Wyo. Moisture, 15.17 per cent; volatile matter, 35.31 per cent; fixed carbon, 45.82 per cent; ash, 3.70 per cent; sulphur, 0.40 per cent.

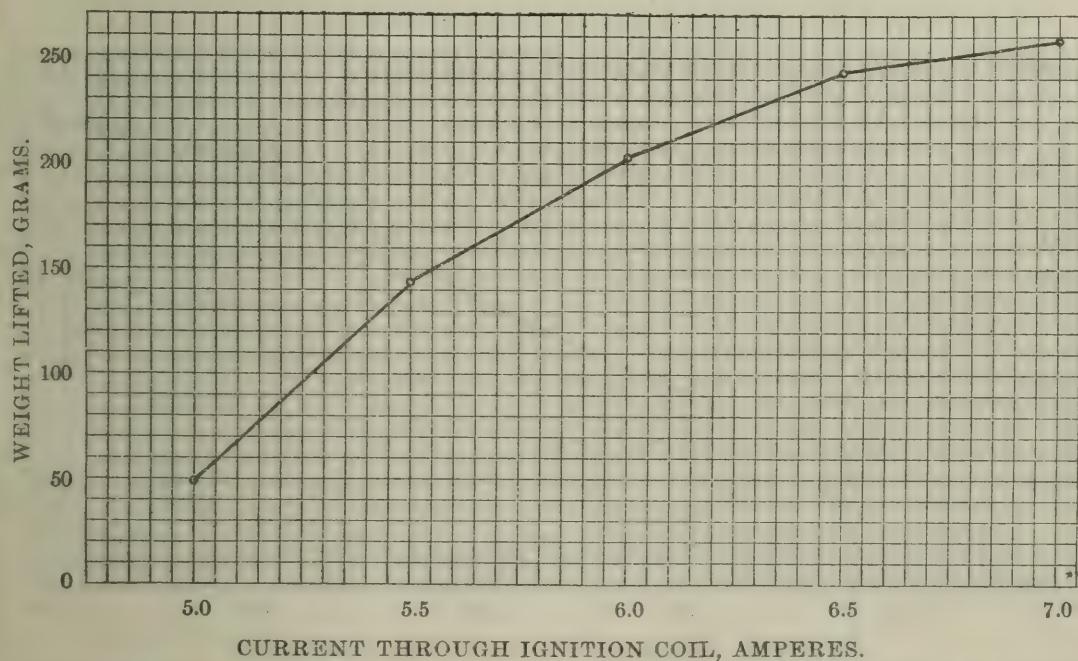


FIGURE 65.—Relative inflammability of coal No. 10827, Johnson County, Wyo. Moisture, 15.52 per cent; volatile matter, 39.34 per cent; fixed carbon, 39.43 per cent; ash, 5.71 per cent; sulphur, 0.64 per cent.

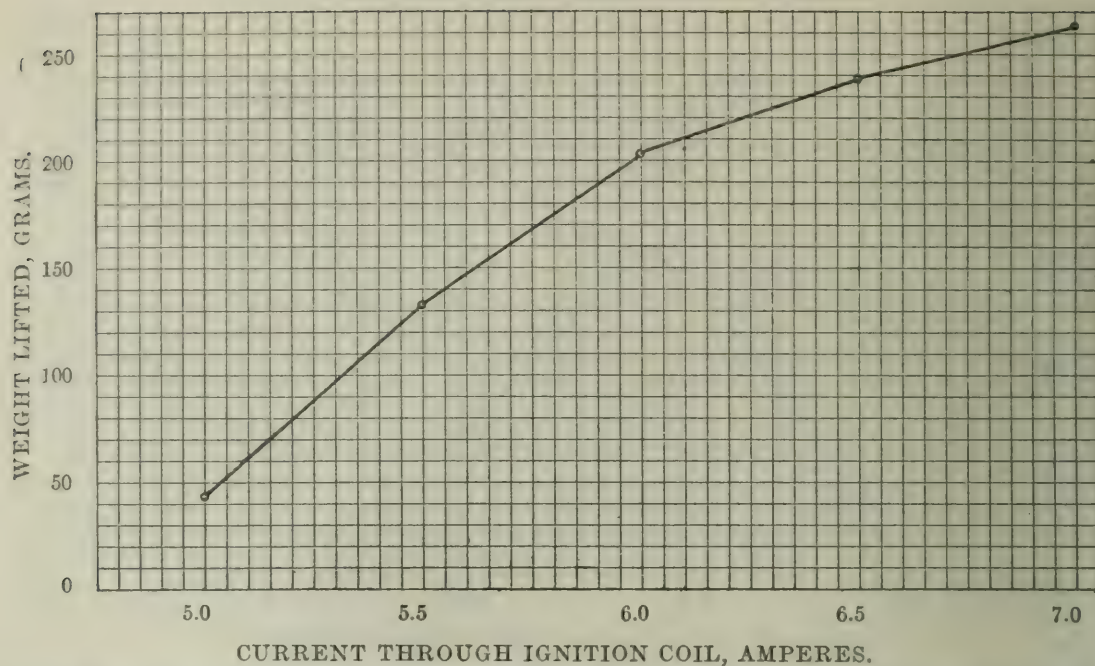


FIGURE 66.—Relative inflammability of coal No. 10825, Sheridan County, Wyo. Moisture, 13.49 per cent; volatile matter, 36.33 per cent; fixed carbon, 45.10 per cent; ash, 5.08 per cent; sulphur, 0.34 per cent.

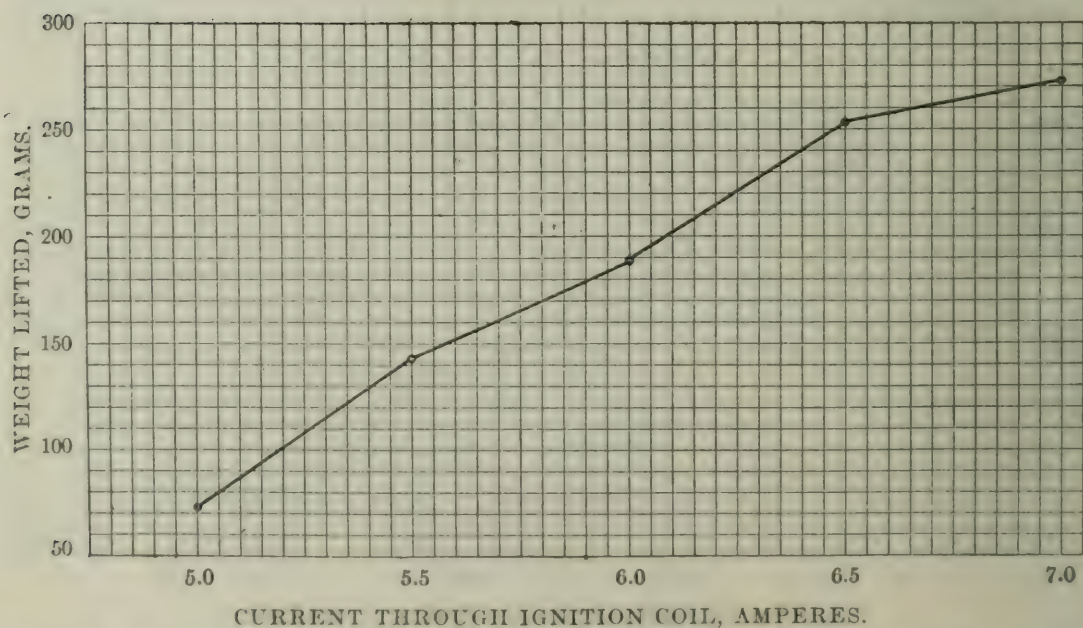


FIGURE 67.—Relative inflammability of coal No. 11048, Converse County, Wyo. Moisture, 16.08 per cent; volatile matter, 36.91 per cent; fixed carbon, 41.62 per cent; ash, 5.39 per cent; sulphur, 0.53 per cent.

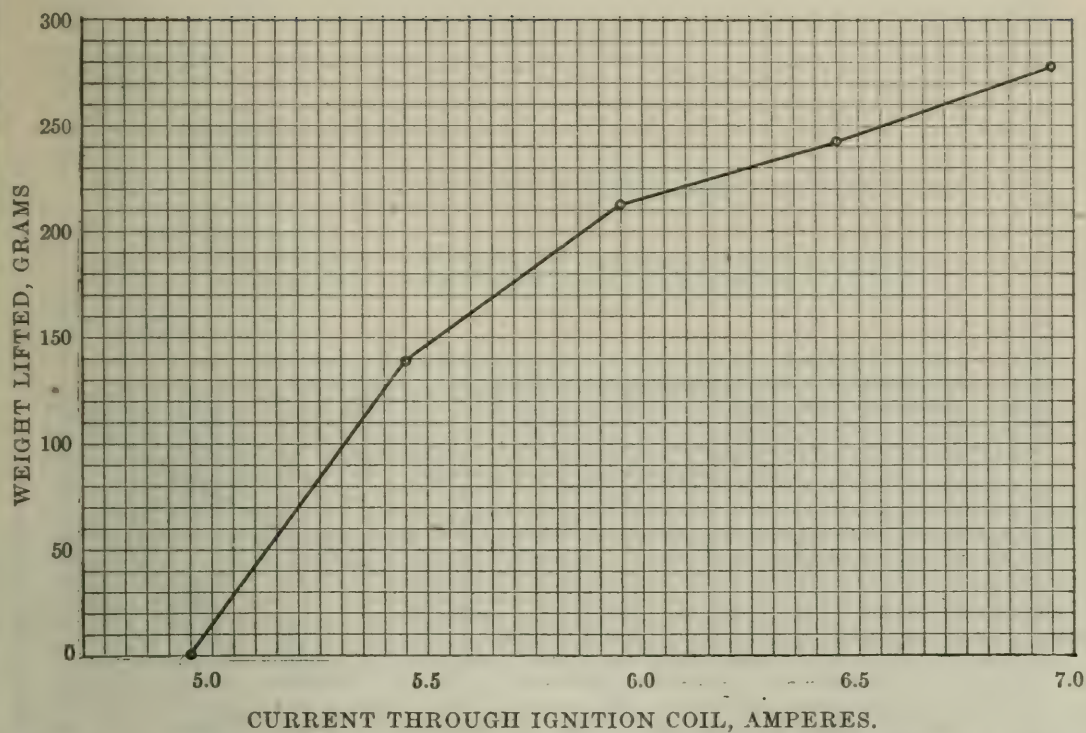


FIGURE 68.—Relative inflammability of coal No. 10822, Sheridan County, Wyo. Moisture, 13.94 per cent; volatile matter, 35.12 per cent; fixed carbon, 45.44 per cent; ash, 5.50 per cent; sulphur, 0.56 per cent.

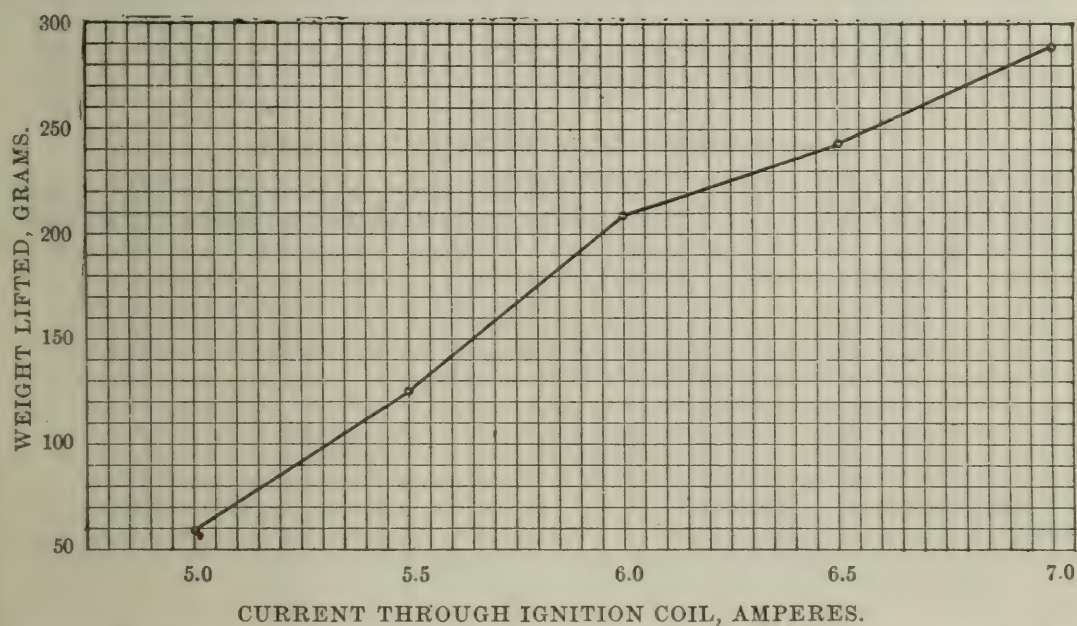


FIGURE 69.—Relative inflammability of coal No. 12006, Sheridan County, Wyo. Moisture, 14.90 per cent; volatile matter, 37.28 per cent; fixed carbon, 43.82 per cent; ash, 4.00 per cent; sulphur, 0.43 per cent.

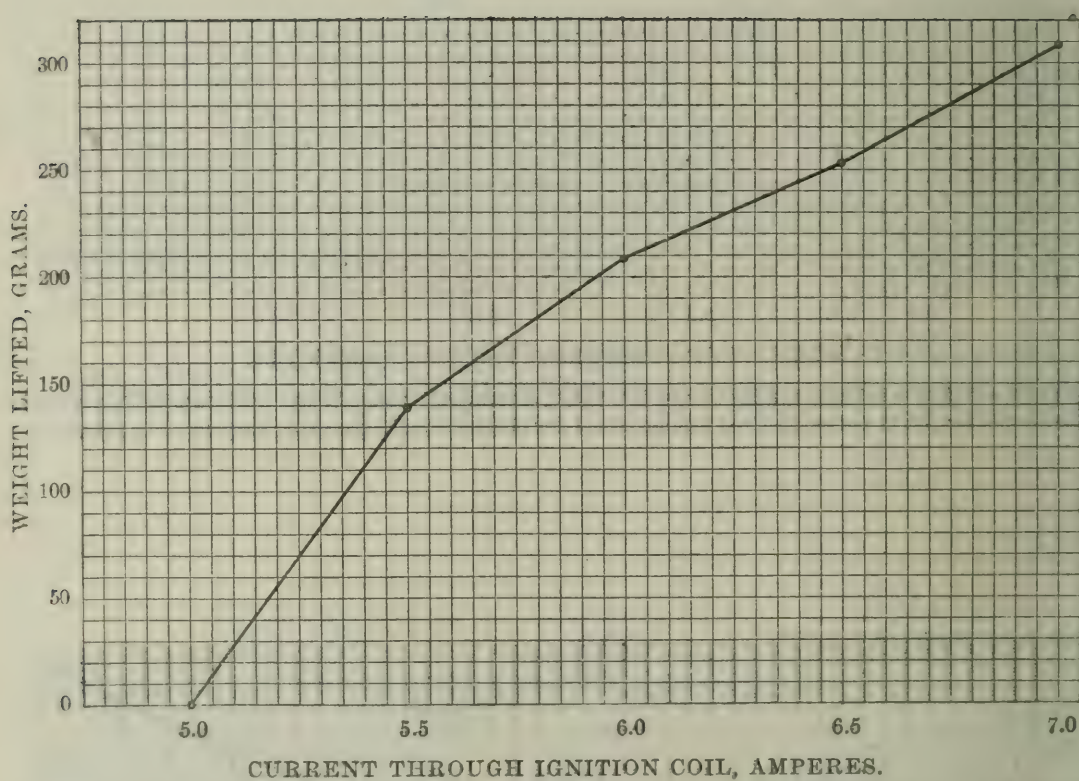


FIGURE 70.—Relative inflammability of coal No. 12003, Sheridan County, Wyo. Moisture, 14.97 per cent; volatile matter, 35.24 per cent; fixed carbon, 46.22 per cent; ash, 3.57 per cent; sulphur, 0.41 per cent.

TABLE 3.—Dusts of group 2, road dusts.

Laboratory number and description.	Chemical analysis (air-dried sample).						In-flam-mability. ^a	Weight lifted at different current strengths.				
	Mois-ture.	Volatile matter.	Fixed carbon.	Ash.	Sul-phur.	Oxy-gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.		Grams.	Grams.	Grams.	Grams.	Grams.
12024. Colorado, Las Animas County; Primero; Primero mine; bituminous coal (coked).	0.91	16.73	59.13	23.23	0.66	1.54	1	.....	.....	.....	.....	.....
11936. Colorado, Las Animas County; Cokedale mine; bituminous coal.	1.11	20.44	38.99	39.46	.43	.86	2	.....	3	8	18	60
11678. Ohio; bituminous coal.	2.22	22.21	36.79	38.78	1.29	.....	3	.....	13	18	43	73
11136. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	2.02	14.85	21.35	61.78	.29	.....	4	.....	3	8	68	83
11931. Colorado, Las Animas County; Forbes; Forbes No. 9 mine; bituminous coal.	1.58	24.72	38.86	34.84	.52	.....	5	.....	8	23	123	123
11140. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.11	27.31	46.08	25.50	.62	.....	6	.....	8	18	73	128
11142. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.19	26.55	43.34	28.92	.58	.....	7	.....	10	23	78	128
11141. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	.99	25.61	44.69	28.71	.49	.....	8	.....	8	18	103	128
11434. Colorado, Las Animas County; Delagua; Delagua mine; bituminous coal.	1.33	27.61	37.42	33.64	.64	.....	9	.....	5	8	43	130
11571. Oklahoma, Pittsburg County; 2 miles east of McAlester; Busby No. 5 mine; McAlester bed; bituminous coal.	1.52	25.78	42.43	30.27	.50	.....	10	.....	8	13	98	133
11139. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.15	26.08	47.22	24.95	.53	.....	11	.....	5	23	93	143
11438. Colorado, Las Animas County; Delagua; Delagua mine; bituminous coal.	1.43	27.87	36.39	34.31	.82	.....	12	.....	3	8	38	145

^a The relative inflammability of the dusts is based on the results of the tests in which the greatest current strength was on the wire (see p. 8), and the dust least inflammable with that current strength under the conditions of the tests is ranked 1 in this table.

TABLE 3.—*Dusts of group 2, road dusts—Continued.*

Laboratory number and description.	Chemical analysis (air-dried sample).						In-flam-mabil-ity.	Weight lifted at different current weights.				
	Mois-ture.	Volatile matter.	Fixed carbon.	Ash.	Sul-phur.	Oxy-gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.
11137. Colorado, Las Animas County; Starkville mine; Engleville-Starkville bed; bituminous coal.	<i>P. ct.</i> 0.91	<i>P. ct.</i> 20.80	<i>P. ct.</i> 35.11	<i>P. ct.</i> 43.18	<i>P. ct.</i> 0.40	<i>P. ct.</i>	13	<i>Grams.</i>	<i>Grams.</i> 13	<i>Grams.</i> 18	<i>Grams.</i> 123	<i>Grams.</i> 143
11133. Pennsylvania, Allegheny County; Creighton; Hite mine; Freeport bed; bituminous (cannel) coal.	.72	26.28	36.59	36.41	1.59	.....	14	.....	18	43	138	148
11138. Colorado, Las Animas County; Starkville; Starkville mine; Engleville-Starkville bed; bituminous coal.	1.02	29.69	51.47	17.82	.61	.....	15	.....	18	48	78	153
11439. Colorado, Las Animas County; Delagua; Delagua mine; bituminous coal.	1.25	30.40	38.12	30.23	.75	.....	16	.....	3	13	33	163
11593. Oklahoma, Pittsburg County; 2 miles east of Alderson; Alderson mine; McAlester bed; bituminous charred dust.	1.70	31.65	54.20	12.45	.53	.....	17	.....	10	18	133	168
11570. Oklahoma, Pittsburg County; 2 miles east of McAlester; Busby No. 5 mine; McAlester bed; bituminous coal.	1.45	29.05	51.20	18.30	.65	.....	18	.....	10	23	158	168
12002. Wyoming, Sheridan County; Monarch; Monarch mine; Monarch bed; subbituminous coal.	10.54	34.53	43.58	11.35	.99	.....	19	5	38	168	238	263
12003. Wyoming, Sheridan County; Monarch; Monarch mine; Monarch bed; subbituminous coal.	8.17	35.18	46.45	10.20	1.27	.....	20	23	128	165	228	283
12007. Wyoming, Sheridan County; Monarch; Monarch mine; Monarch bed; subbituminous coal.	8.95	37.62	45.96	7.47	1.07	.....	21	23	128	203	253	300

TABLE 4.—Dusts of group 3, mixtures of coal dust with shale or with calcium chloride.

Laboratory number and description.	Chemical analysis (air-dried coal).						Inflam- mabil- ity. ^a	Weight lifted at different current strengths.					For curve see fig- No.—
	Mois- ture.	Volatile matter.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.		5.0 am- peres.	5.5 am- peres.	6.0 am- peres.	6.5 am- peres.	7.0 am- peres.	
11184. Kansas, Crawford County; Fuller; No. 2 shaft. 11184+10 per cent shale. 11184+20 per cent shale. 11184+30 per cent shale. 11184+40 per cent shale. 11184+50 per cent shale.	Per ct. 1.50	Per ct. 34.71	Per ct. 54.37	Per ct. 9.42	Per ct. 5.12	Per ct. 5.60	1	15 11 10 9 8	45 40 35 30 20	110 90 75 55 20	195 170 140 100 65	215 185 160 140 95	71
11188. Missouri, Barton County, 2 miles northwest of Minden Mines, No. 7 shaft. 11188+10 per cent calcium carbonate. 11188+20 per cent calcium carbonate. 11188+30 per cent calcium carbonate. 11188+40 per cent calcium carbonate. 11188+50 per cent calcium carbonate.	1.64	32.37	53.99	12.00	5.22	6.16	2	13	73	133	215	233	72
10736. Virginia, Russell County, 2 miles north of Dante; No. 2 mine; Upper Banner bed. 10736+10 per cent shale. 10736+20 per cent shale. 10736+30 per cent shale. 10736+40 per cent shale. 10736+50 per cent shale.	.98	35.60	57.54	5.88	.60	5.25	3	15	75	140	205	240	73
10909. Utah, Carbon County; Hiawatha; Hiawatha No. 2 mine; Hiawatha (?) bed. 10909+10 per cent shale. 10909+20 per cent shale. 10909+30 per cent shale. 10909+40 per cent shale. 10909+50 per cent shale.	3.33	41.79	47.76	7.12	.57	13.89	4	50	100	175	245	275	74
10825. Wyoming, Sheridan County; Acme; Acme No. 1 mine; "Carney vein", 10825+10 per cent shale. 10825+20 per cent shale. 10825+30 per cent shale. 10825+40 per cent shale. 10825+50 per cent shale.	13.49	36.33	45.10	5.08	.34	27.93	5	45	105	200	250	280	75
								40	95	180	235	270	
								35	95	170	220	245	
								25	70	145	180	200	
								15	30	100	135	155	
										60	100	125	

^a The relative inflammability of the dusts is based on the results of the tests in which the greatest current strength was on the wire (see p. 8), and the dust least inflammable with that current strength under the conditions of the tests is ranked 1 in this table.

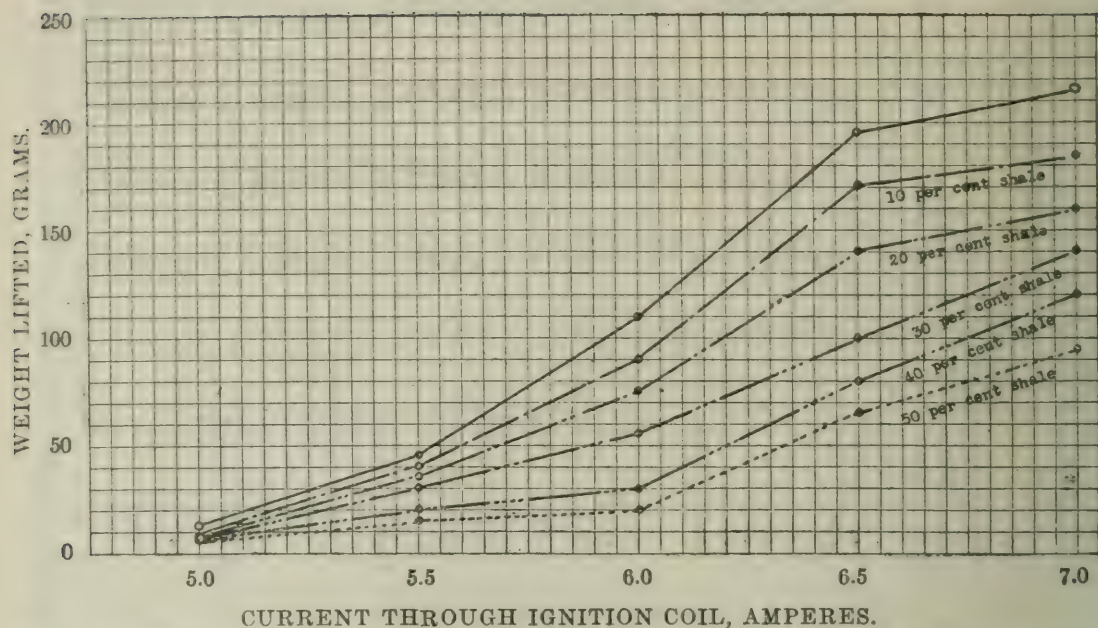


FIGURE 71.—Relative inflammability of coal No. 11184, Crawford County, Kans., and of mixtures of coal No. 11184 with shale. Moisture, 1.50 per cent; volatile matter, 34.71 per cent; fixed carbon, 54.37 per cent; ash, 9.42 per cent; sulphur, 5.12 per cent.

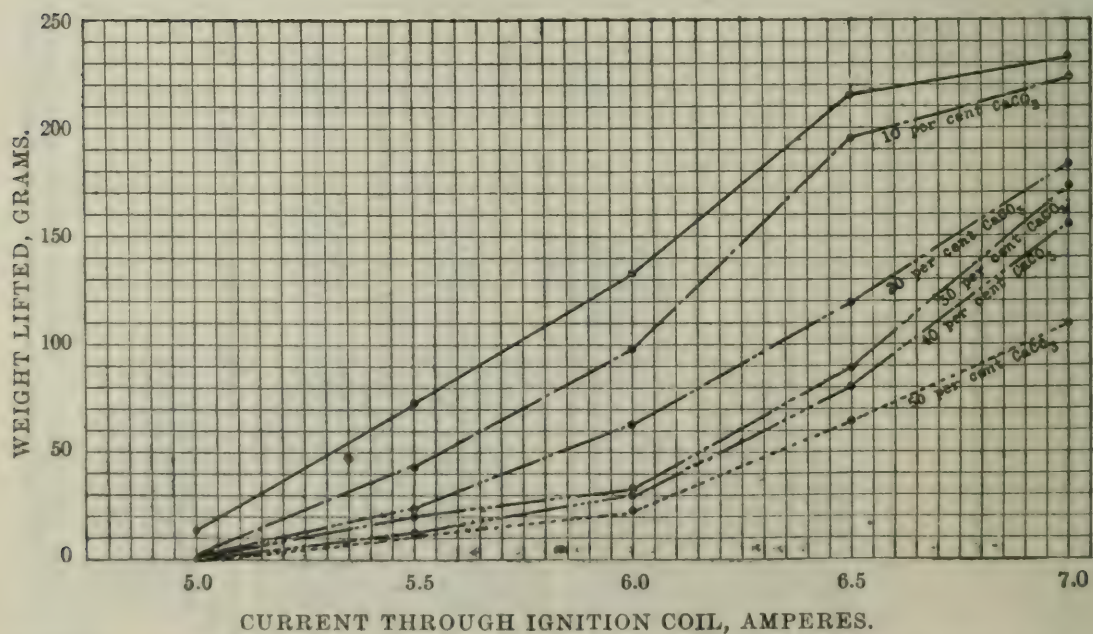


FIGURE 72.—Relative inflammability of coal No. 11188, Barton County, Mo., and of mixtures of coal No. 11188 with calcium carbonate. Moisture, 1.64 per cent; volatile matter, 32.37 per cent; fixed carbon, 53.99 per cent; ash, 12 per cent; sulphur, 5.22 per cent.

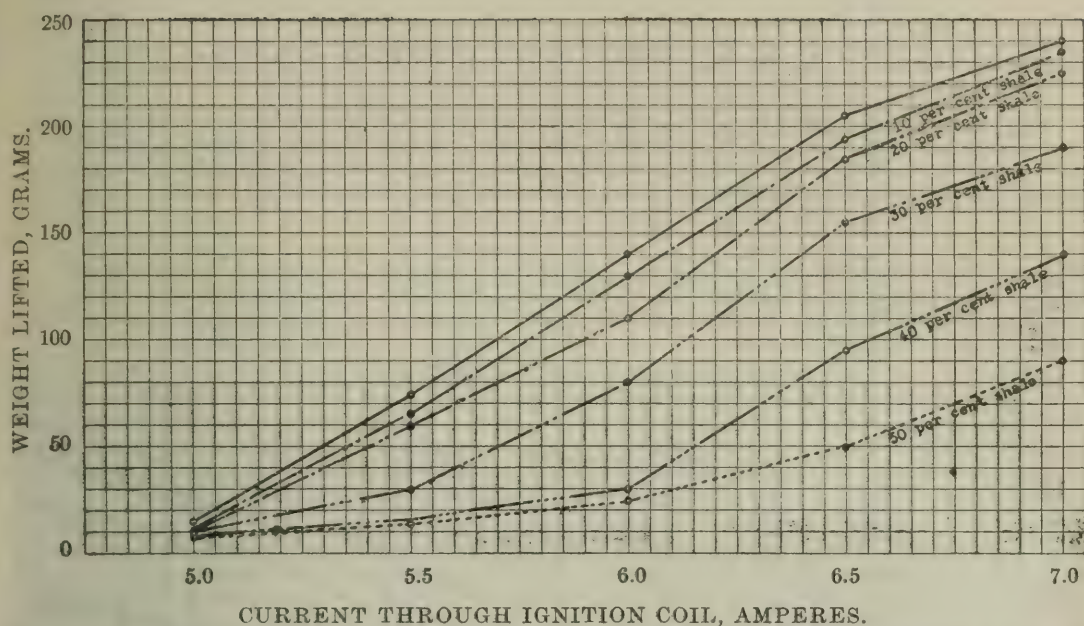


FIGURE 73.—Relative inflammability of coal No. 10736, Russell County, Va., and of mixtures of coal No. 10736 with shale. Moisture, 0.98 per cent; volatile matter, 35.60 per cent; fixed carbon, 57.54 per cent; ash, 5.88 per cent; sulphur, 0.60 per cent.

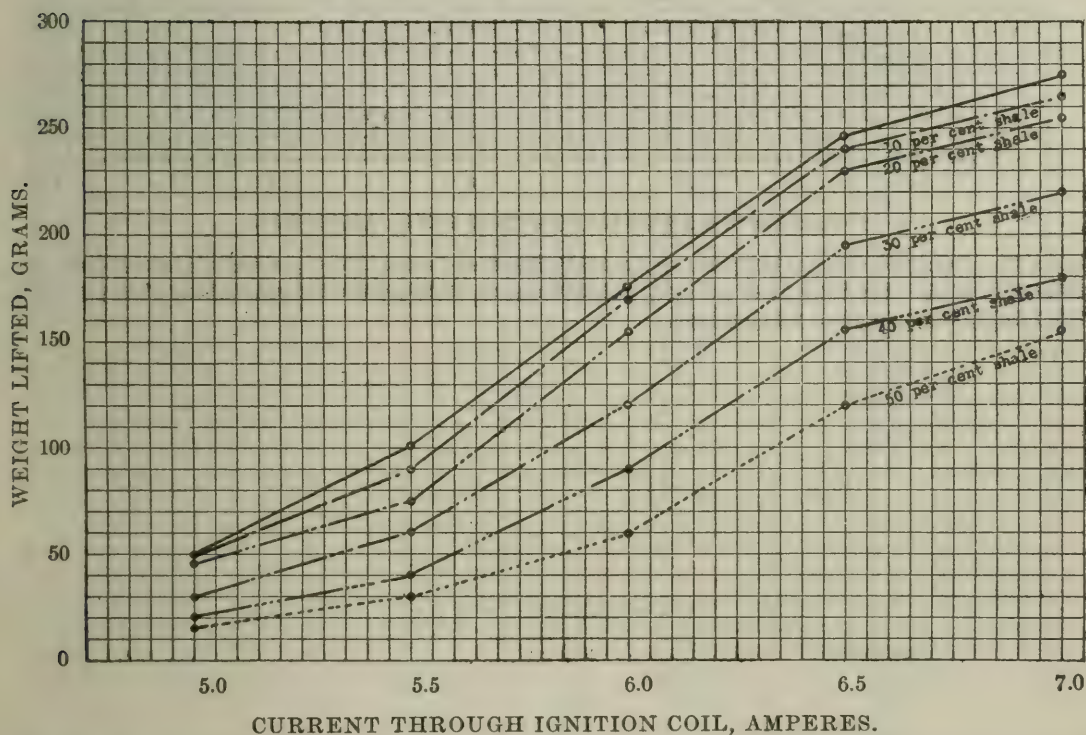


FIGURE 74.—Relative inflammability of coal No. 10909, Carbon County, Utah, and of mixtures of coal No. 10909 with shale. Moisture, 3.33 per cent; volatile matter, 41.79 per cent; fixed carbon, 47.76 per cent; ash, 7.12 per cent; sulphur, 0.57 per cent.

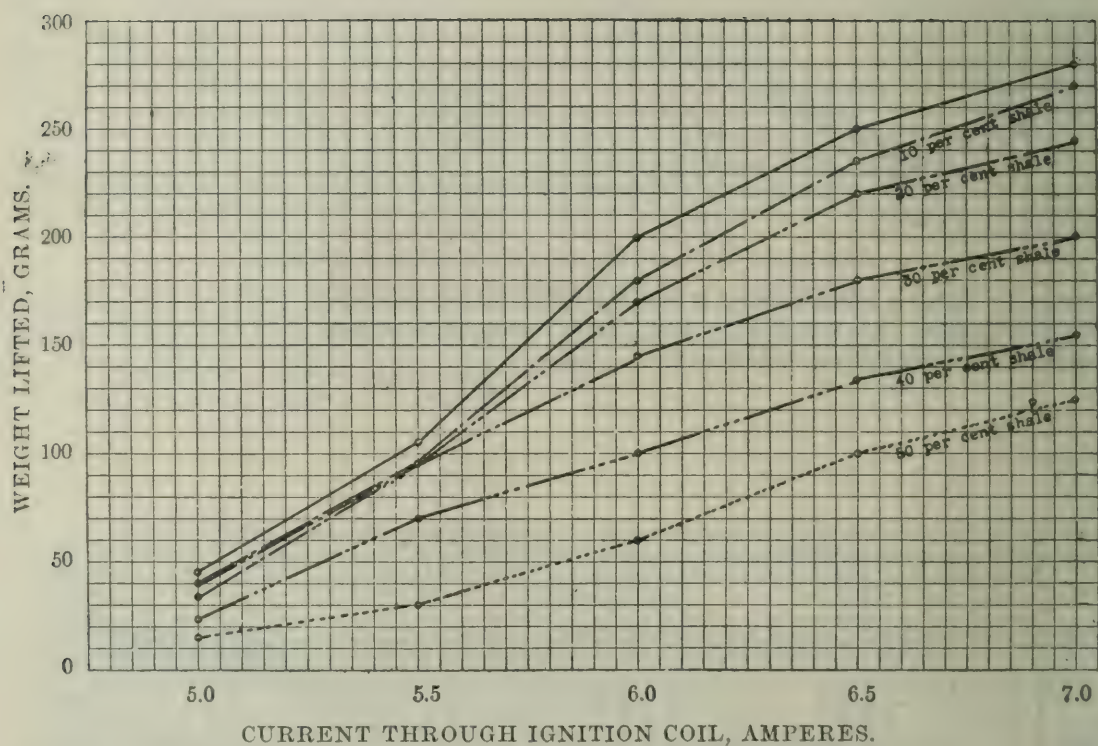


FIGURE 75.—Relative inflammability of coal No. 10825, Sheridan County, Wyo., and of mixtures of coal No. 10825 with shale. Moisture, 13.49 per cent; volatile matter, 36.33 per cent; fixed carbon, 45.10 per cent; ash, 5.08 per cent; sulphur, 0.34 per cent.

TABLE 5.—*Dusts of group 4, inflammable dusts other than coal dust.*

Laboratory number and description.	(Chemical analysis (air-dried coal).						Inflam- mabil- ity. ^a	Weight lifted at different current strengths.					For curve see fig. No. —
	Mois- ture.	Volatile matter.	Fixed carbon.	Ash.	Sul- phur.	Oxy- gen.		5.0 amp.	5.5 amp.	6.0 amp.	6.5 amp.	7.0 amp.	
11190. Flour.....	P. ct. 11.09	P. ct. 63.58	P. ct. 24.90	P. ct. 0.43	P. ct.	P. ct.	1	Grams. 98	Grams. 118	Grams. 148	Grams. 158	Grams. 188	76
11689. Pine dust.....	4.38	71.92	16.02	7.68	.....	.....	2	13	18	43	178	218	77
11688. Oak dust.....	3.22	77.05	16.56	3.17	.....	.....	3	140	143	183	228	238	78
11386. Asphalt; Oklahoma; Pushmataha County; Jumbo; Jumbo mine.	.29	44.67	48.07	6.97	1.60	1.80	4	105	180	218	235	243	79
11388. Asphalt; Oklahoma; Pushmataha County; Jumbo; Jumbo mine.	.21	43.98	49.19	6.62	1.63	1.85	5	75	140	220	235	243	80
11387. Asphalt; Oklahoma; Pushmataha County; Jumbo; Jumbo mine.	.34	44.50	48.37	6.79	1.61	1.56	6	125	178	228	238	243	81
11189. Starch.....	14.58	70.21	14.87	.34	.....	.....	7	48	188	228	243	248	82
11389. Asphalt; Oklahoma; Pushmataha County; Jumbo; Jumbo mine.	.24	43.36	50.70	5.70	1.62	2.26	8	125	170	233	253	258	83
13331. Sugar.....	.00	95.15	4.85	.00	.....	.....	9	268	288	293	298	300	84
11690. Mahogany dust.....	5.55	72.71	19.91	1.83	.....	.....	10	138	160	193	288	308	85
13232. Lycopodium.....	2.04	87.39	8.98	1.59	.11	.....	11	400	435	520	530	540	86

^aThe relative inflammability of the dusts is based on the results of the tests in which the greatest current strength was on the wire (see p. 8), and the dust least inflammable with that current strength under the conditions of the tests is ranked 1 in this table.

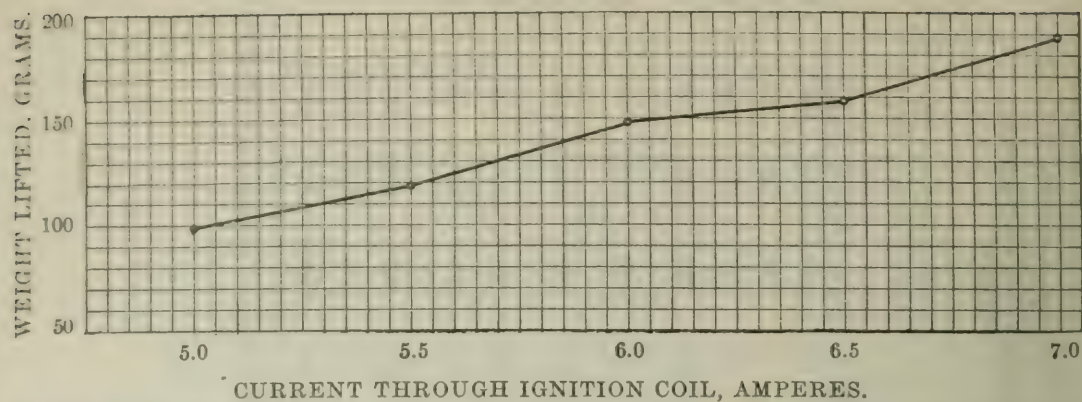


FIGURE 76.—Relative inflammability of flour, No. 11190. Moisture, 11.09 per cent; volatile matter, 63.58 per cent; fixed carbon, 24.90 per cent; ash, 0.43 per cent.

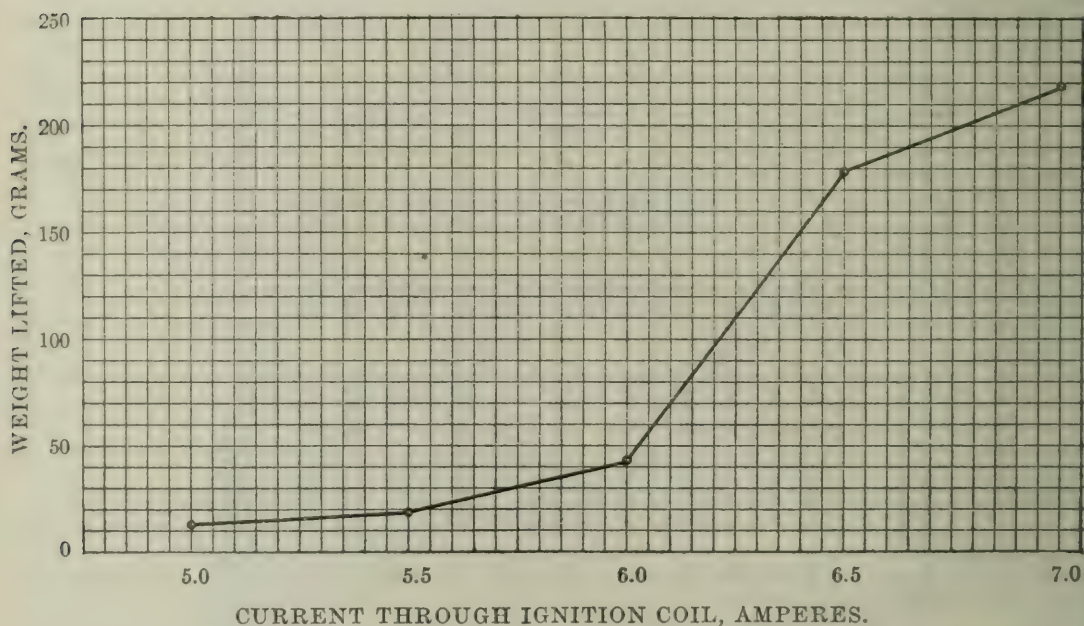


FIGURE 77.—Relative inflammability of pine dust, No. 11689. Moisture, 4.38 per cent; volatile matter, 71.92 per cent; fixed carbon, 16.02 per cent; ash, 7.68 per cent.

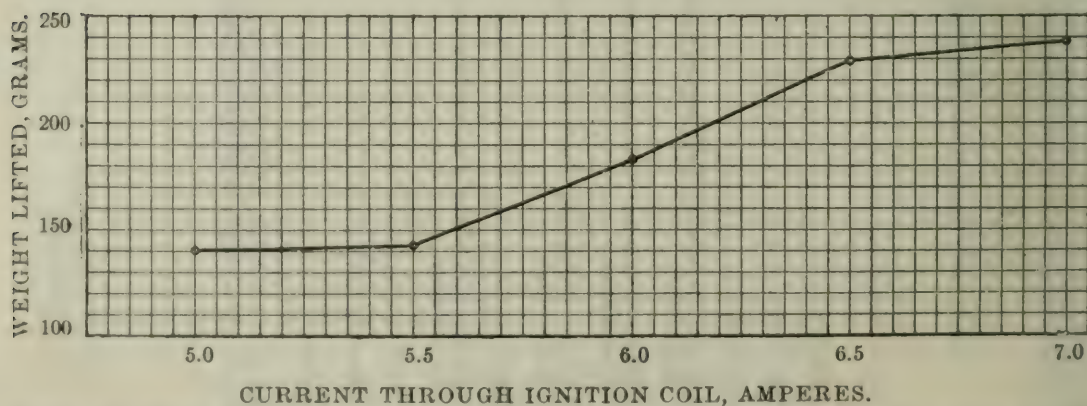


FIGURE 78.—Relative inflammability of oak dust, No. 11688. Moisture, 3.22 per cent; volatile matter, 77.05 per cent; fixed carbon, 16.56 per cent; ash, 3.17 per cent.

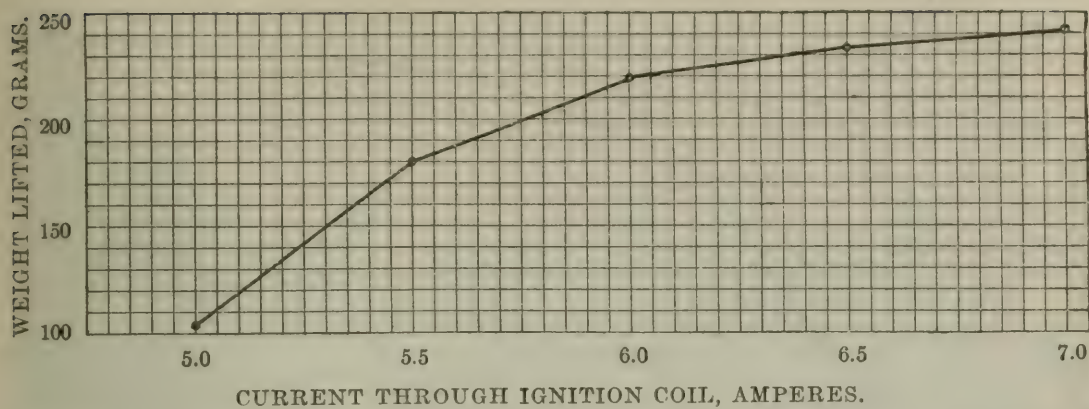


FIGURE 79.—Relative inflammability of asphalt No. 11386, Pushmataha County, Okla. Moisture, 0.29 per cent; volatile matter, 44.67 per cent; fixed carbon, 48.07 per cent; ash, 6.97 per cent; sulphur, 1.60 per cent.

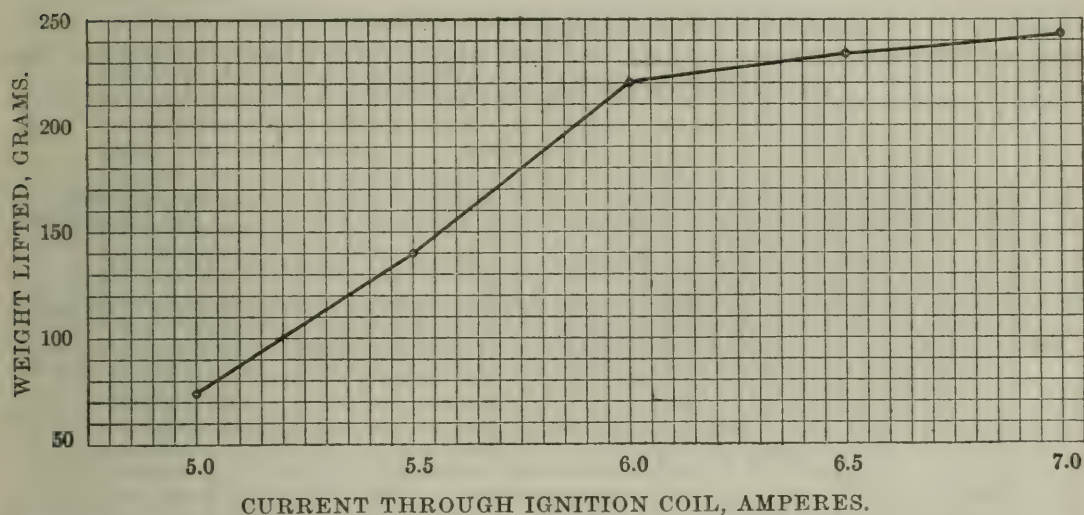


FIGURE 80.—Relative inflammability of asphalt No. 11388, Pushmataha County, Okla. Moisture, 0.21 per cent; volatile matter, 43.98 per cent; fixed carbon, 49.19 per cent; ash, 6.62 per cent; sulphur, 1.63 per cent.

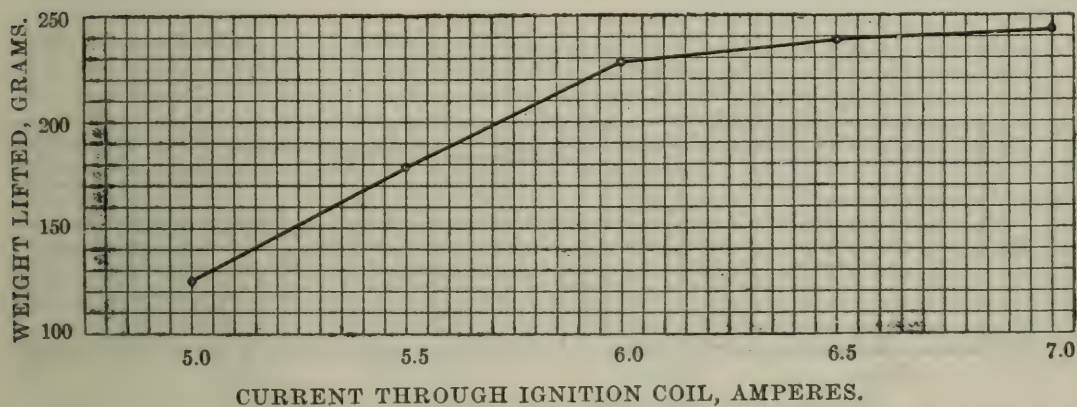


FIGURE 81.—Relative inflammability of asphalt No. 11387, Pushmataha County, Okla. Moisture, 0.34 per cent; volatile matter, 44.50 per cent; fixed carbon, 48.37 per cent; ash, 6.79 per cent; sulphur, 1.61 per cent.

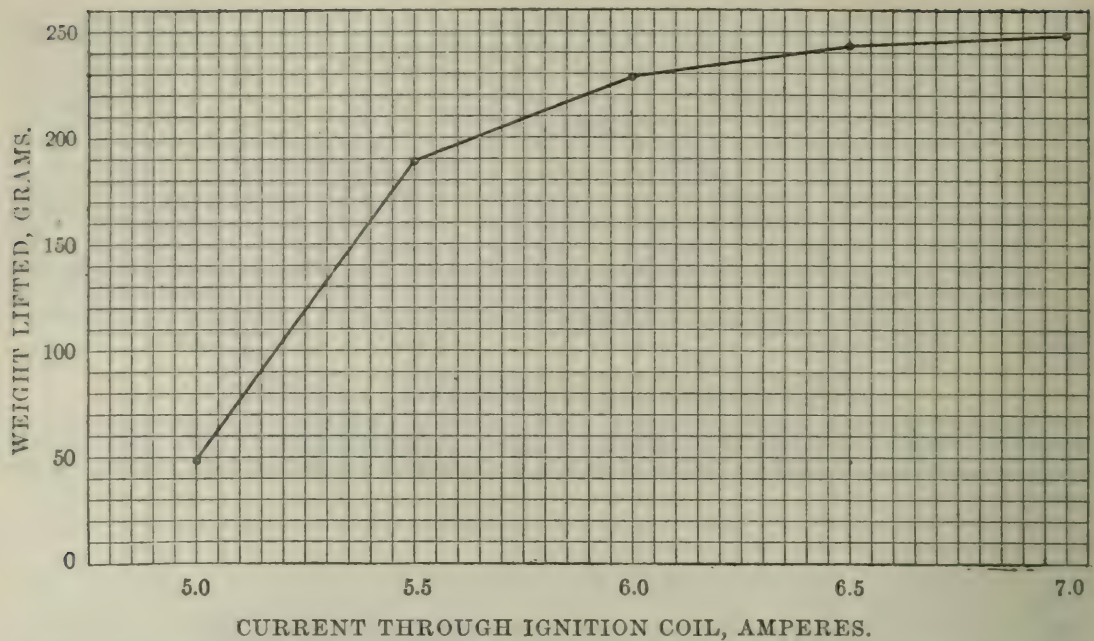


FIGURE 82.—Relative inflammability of starch, No. 11189. Moisture, 14.58 per cent; volatile matter, 70.21 per cent; fixed carbon, 14.87 per cent; ash, 0.34 per cent.

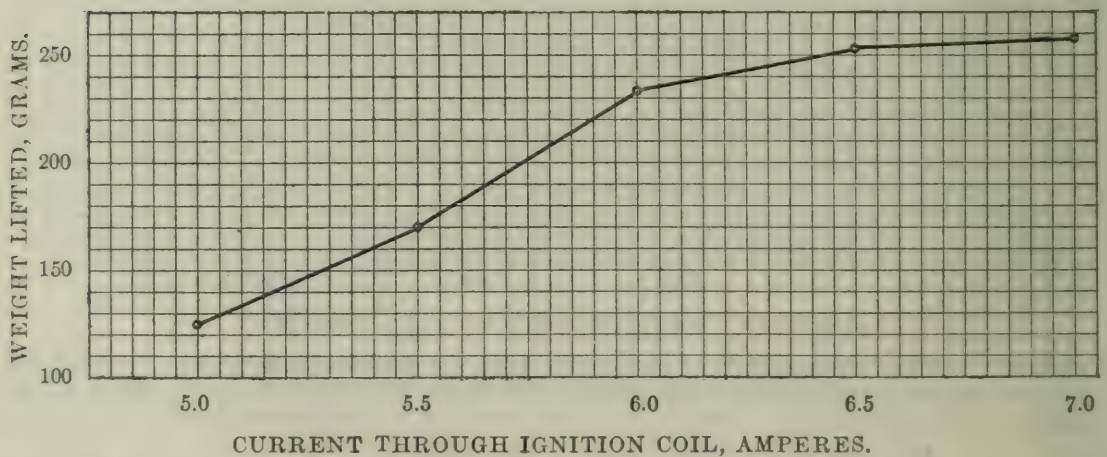


FIGURE 83.—Relative inflammability of asphalt No. 11389, Pushmataha County, Okla. Moisture, 0.24 per cent; volatile matter, 43.36 per cent; fixed carbon, 50.70 per cent; ash, 5.70 per cent; sulphur, 1.62 per cent.

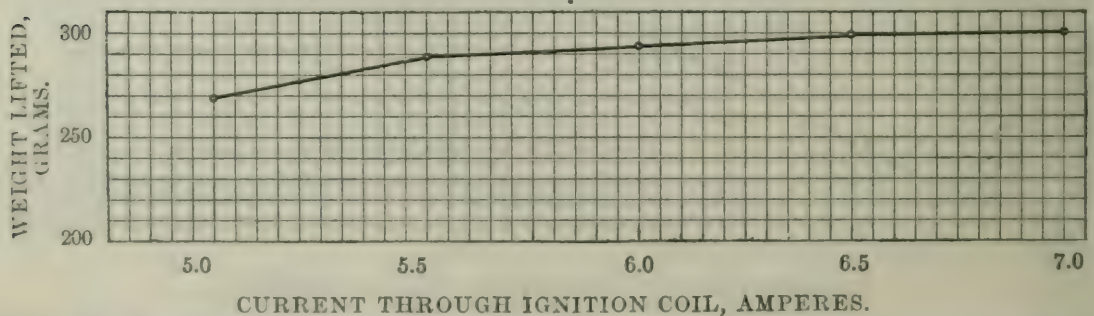


FIGURE 84.—Relative inflammability of sugar, No. 13331. Moisture, 0.00 per cent; volatile matter, 95.15 per cent; fixed carbon, 4.85 per cent; ash, 0.00 per cent.

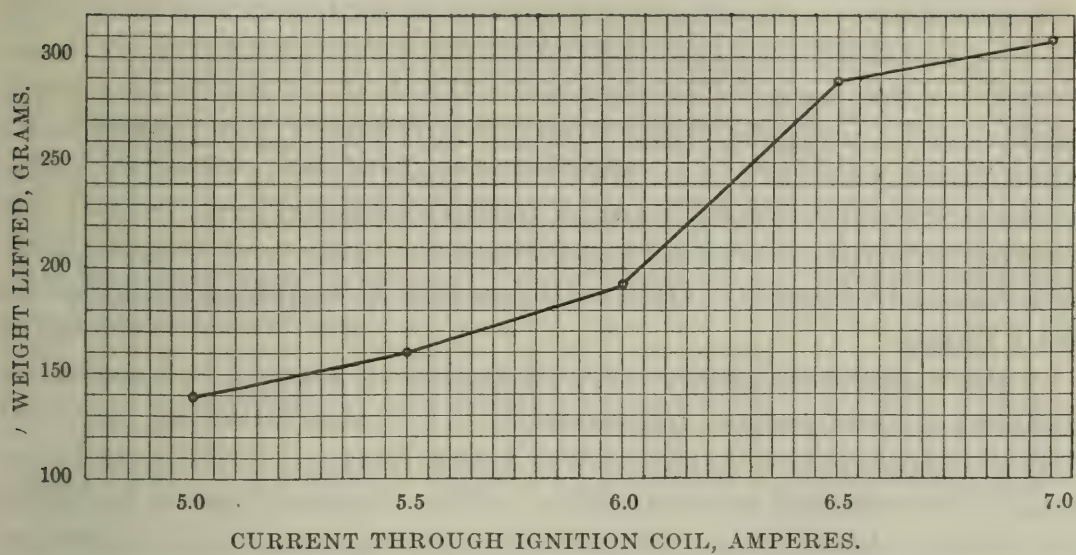


FIGURE 85.—Relative inflammability of mahogany dust, No. 11690. Moisture, 5.55 per cent; volatile matter, 72.71 per cent; fixed carbon, 19.91 per cent; ash, 1.83 per cent.

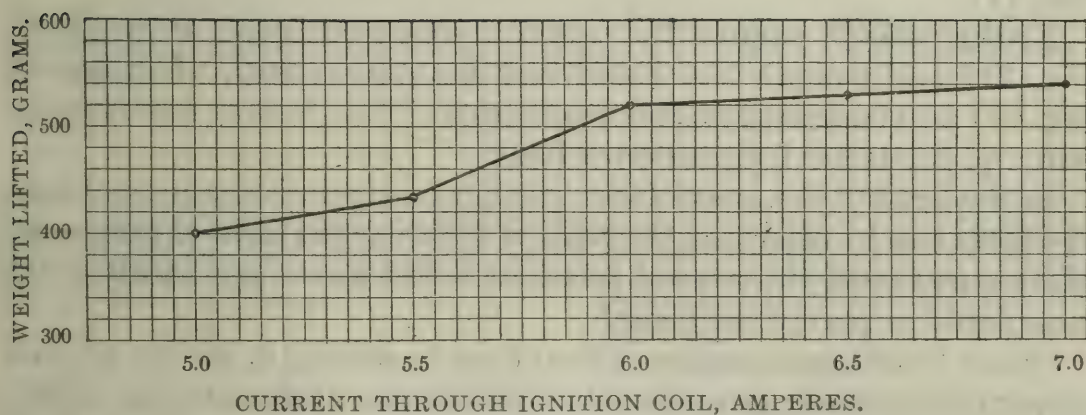


FIGURE 86.—Relative inflammability of lycopodium, No. 13332. Moisture, 2.04 per cent; volatile matter, 87.39 per cent; fixed carbon, 8.98 per cent; ash, 1.59 per cent; sulphur, 0.11 per cent.

DISCUSSION OF RESULTS.

In any statement, such as the preceding tables, of the relative inflammability of dusts, ranking of the different samples depends on conditions. In the tables and curves the samples are compared on the basis of the results obtained with the largest current used, namely, 7 amperes. The order of inflammability would have been different if the results obtained at a different current strength had been used, or if the tests had been made on a large scale.

As stated above, the inflammability curves for the various coal dusts are in general of two types, and the dusts of group 1 have been divided on this basis. The curves for the dusts of group 1A ascend continuously throughout their whole length within the range of the experiments, whereas the curves for the coals of group 1B rise rapidly at first and finally become parallel to the horizontal axis. Group 1A includes 50 semibituminous and bituminous coals and 8 subbituminous coals and lignites. Group 1B consists of 9 subbituminous coals and 1 lignite.

Of the 8 subbituminous coals and lignites of group 1A, 4 are to be excluded in comparing inflammability for the following reasons: Coal sample No. 10900 (fig. 3) was taken from an outcrop and was probably weathered, as is indicated by its containing, on a moisture and ash-free basis, 27.47 per cent of oxygen and having a heating value of 5,867 calories as against oxygen, 24.42 per cent and calories 6,455 in the case of sample No. 10899 (fig. 62) taken from the same locality and having a similar proximate analysis. Coal sample No. 11059 (fig. 17) was from an open bank mined for local use and may have been weathered. Coal sample No. 10997 (fig. 32) was from a prospect, and coal sample No. 11058 (fig. 57) was from an abandoned mine.

Attention is called to the extremely high moisture content of sample No. 11361 (fig. 6), the very high ash content of sample No. 10741 (fig. 25), and the high moisture and ash content of sample No. 10732 (fig. 11).

Neither should sample No. 11382, bituminous coal, of group 1A (fig. 31) and sample No. 11048, subbituminous coal, of group 1B (fig. 67) be considered in this connection. The former was from an outcrop, the latter from an open bank.

In the light of the above facts, though no rigid distinction between the coals can be drawn on the basis of difference in form of inflammability curve, still the general relations noted above are hardly to be considered as purely accidental.

Group 3 contains samples of coal dust to which 10, 20, 30, 40, and 50 per cent of finely ground shale or of calcium carbonate was added. These were included in order to measure the effectiveness of this

proposed means of diminishing the inflammability of coal dust. In all the experiments with these artificially prepared dusts, such an amount of each was always taken as contained the same quantity of the pure coal dust that had been used in all the other experiments, so that the same amount of coal dust was in suspension in all cases. The effect of the shale dust in limiting the inflammation is seen with each successive addition, the effect being decidedly marked with the 50 per cent mixture but not sufficient to render the sample noninflammable.

RESULTS OF TESTS WITH EUROPEAN COALS.

In figures 87-94 are given curves of inflammability for coals from France, England, Germany, and Austria. The authors are indebted to G. S. Rice, chief mining engineer, for the samples which he collected personally. The curves are presented without discussion, in the belief that they may prove of interest in connection with the curves previously given.

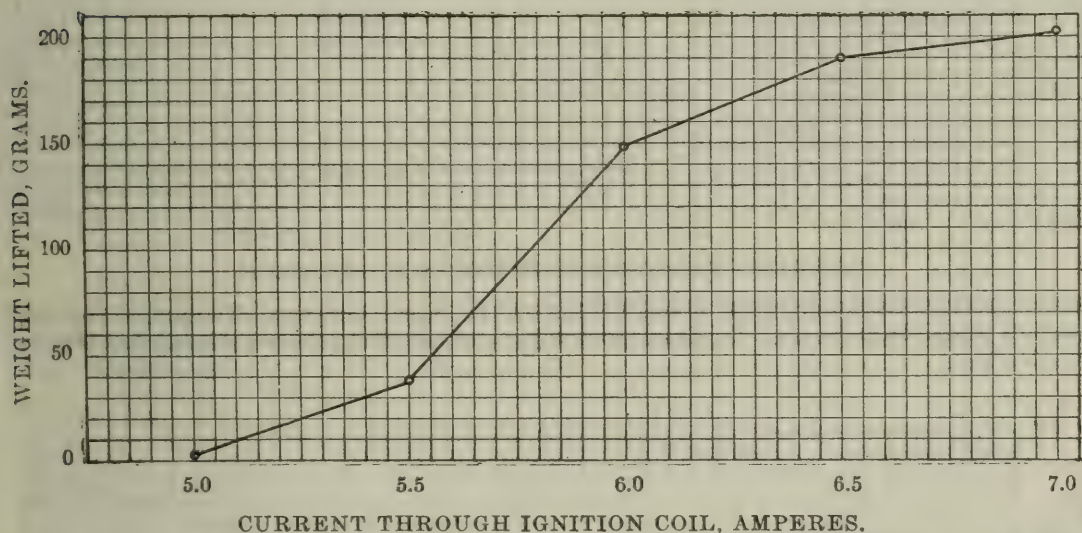


FIGURE 87.—Relative inflammability of coal No. 12653, St. Etienne, France. Moisture, 0.73 per cent; volatile matter, 31.00 per cent; fixed carbon, 66.38 per cent; ash, 1.89 per cent; sulphur, 0.94 per cent. Grab sample.

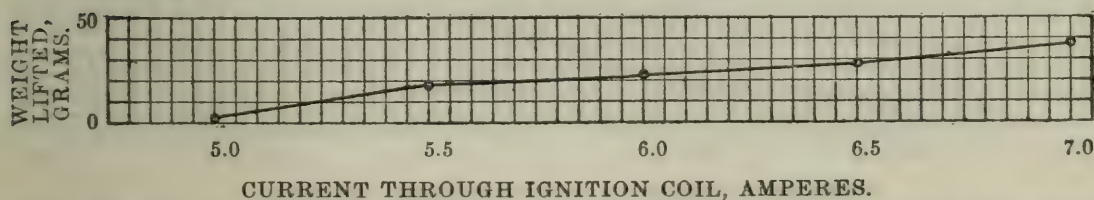


FIGURE 88.—Relative inflammability of coal No. 12654, St. Etienne, France. Moisture, 0.63 per cent; volatile matter, 22.11 per cent; fixed carbon, 63.32 per cent; ash, 13.89 per cent; sulphur, 0.80 per cent. Grab sample.

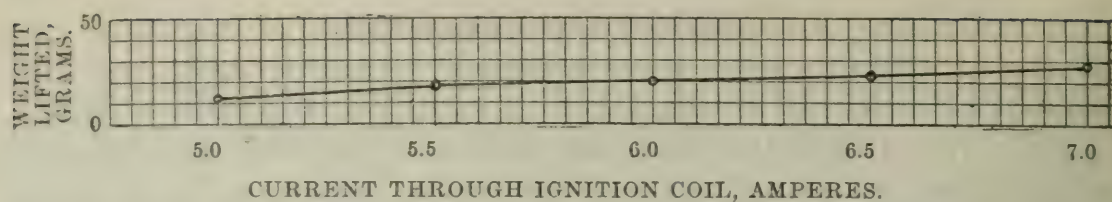


FIGURE 89.—Relative inflammability of coal No. 12655, Ferndale, England. Moisture, 0.78 per cent; volatile matter, 15.78 per cent; fixed carbon, 81.95 per cent; ash, 1.49 per cent; sulphur, 0.59 per cent. Grab sample.

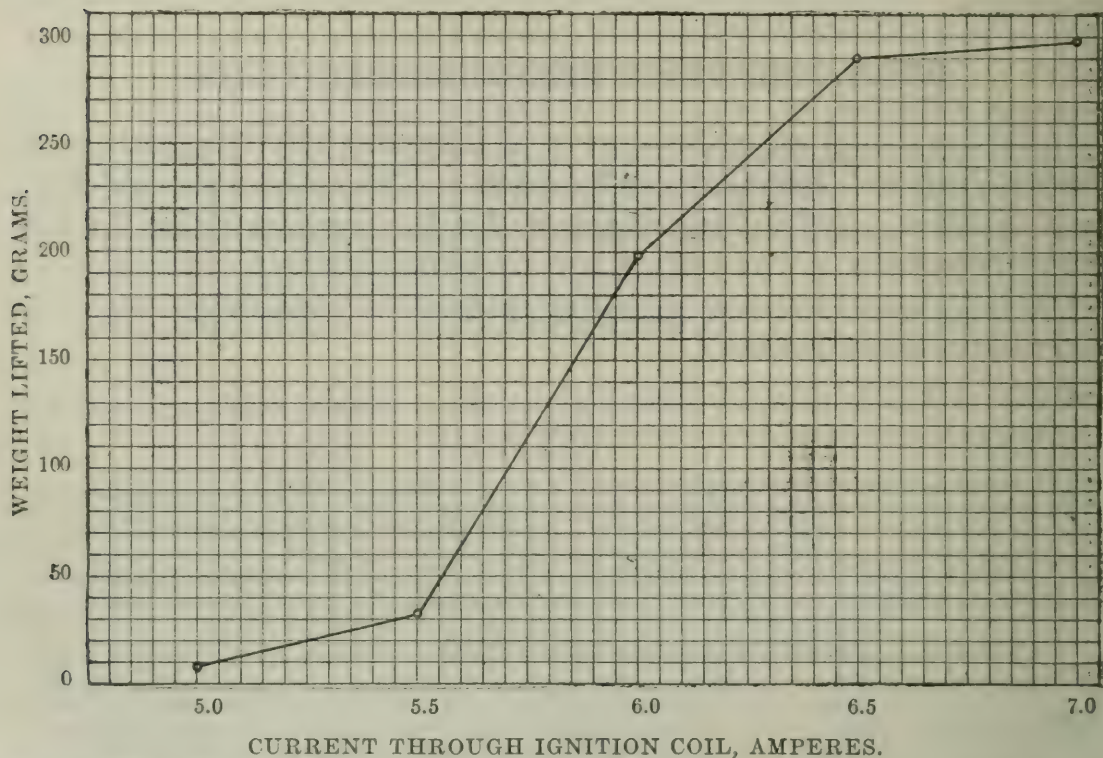


FIGURE 90.—Relative inflammability of coal No. 12656, Upper Silesia, Germany. Moisture, 6.70 per cent; volatile matter, 36.22 per cent; fixed carbon, 54.18 per cent; ash, 2.90 per cent; sulphur, 0.99 per cent. Grab sample.

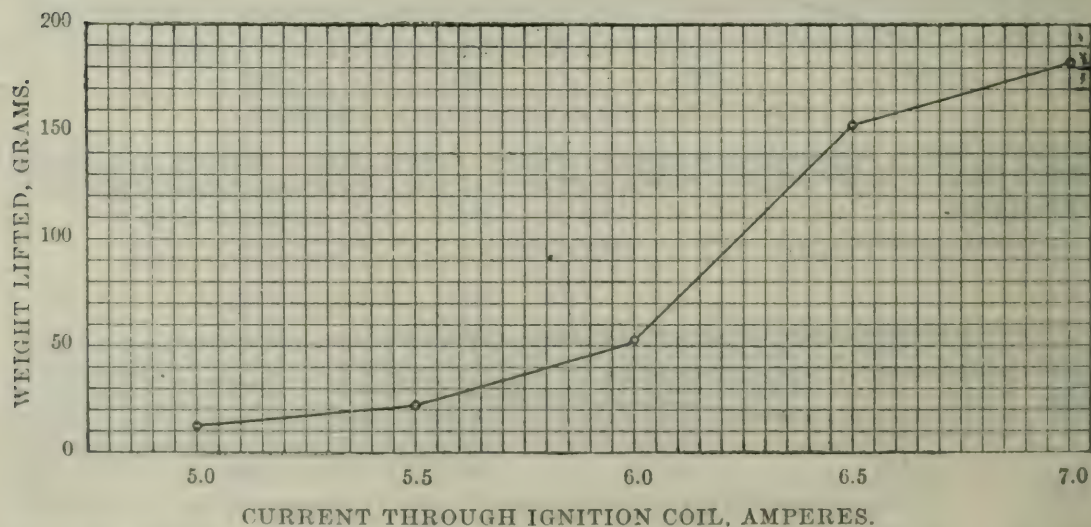


FIGURE 91.—Relative inflammability of coal No. 12657, Westphalia, Germany. Moisture, 1.56 per cent; volatile matter, 30.65 per cent; fixed carbon, 62.66 per cent; ash, 5.13 per cent; sulphur, 0.98 per cent. Grab sample.

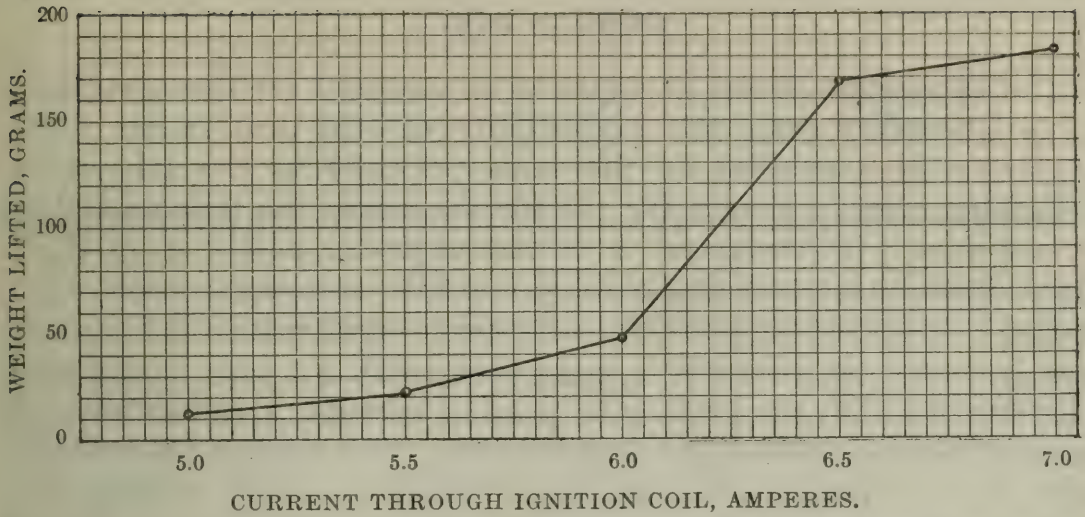


FIGURE 92.—Relative inflammability of coal No. 12658, Westphalia, Germany. Moisture, 1.49 per cent; volatile matter, 33.89 per cent; fixed carbon, 60.04 per cent; ash, 4.58 per cent; sulphur, 1.56 per cent. Grab sample.

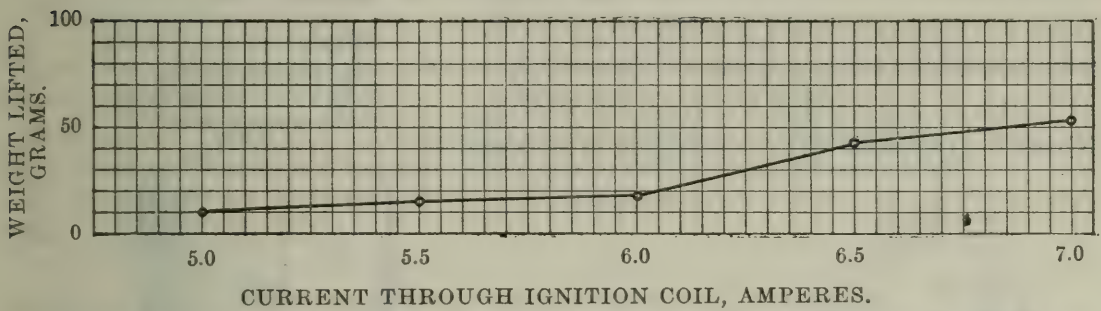


FIGURE 93.—Relative inflammability of coal No. 12659, Westphalia, Germany. Moisture, 0.61 per cent; volatile matter, 18.95 per cent; fixed carbon, 71.59 per cent; ash, 8.85 per cent; sulphur, 1.95 per cent. Grab sample.

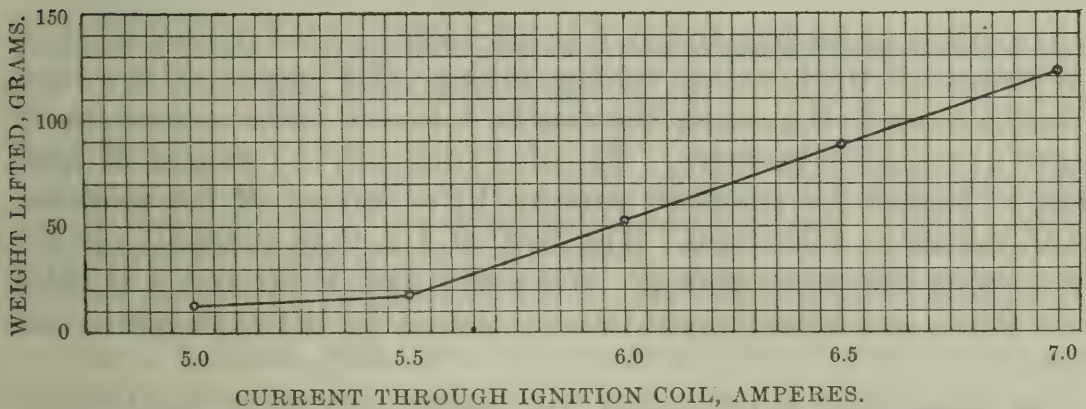


FIGURE 94.—Relative inflammability of coal No. 12660, Segen-Gottes, Austria. Moisture, 0.99 per cent; volatile matter, 20.98 per cent; fixed carbon, 65.17 per cent; ash, 12.86 per cent; sulphur, 3.26 per cent. Standard dust used in Rossitz gallery.

LABORATORY DEMONSTRATION OF INFLAMMABILITY OF COAL DUST IN AIR.

The apparatus shown in figure 95 is designed for demonstrating on a laboratory scale the explosibility of coal dust in air. The apparatus is assembled on the same principle as the laboratory apparatus already shown (fig. 2) for measuring the inflammability of coal dust. It consists of a 14-liter aspirator bottle, *a*, of thick glass, in which is suspended through a rubber stopper, *l*, a coil of 1.5 meters of No. 26 platinum wire. Through another hole in *l* connection is made, by means of a glass tube, with a 1-liter thin-walled Florence flask, *b*, the glass tube passing through a rubber stopper secured in the mouth of the flask by wire. The stopper *l* is held gas tight in *a* by means of a steel piece bolted to a split wooden collar, *c*, clamped around the neck of *a*. Through the tubulure *r*, at the bottom of *a*, is inserted a one-hole rubber stopper carrying a copper funnel, *f*, which is directed upward inside the bottle beneath the coil and is covered with a piece of wire gauze to aid the dissemination of the dust. The stopper carrying *f* is secured in place by wiring. About 5 grams of fine coal dust is placed

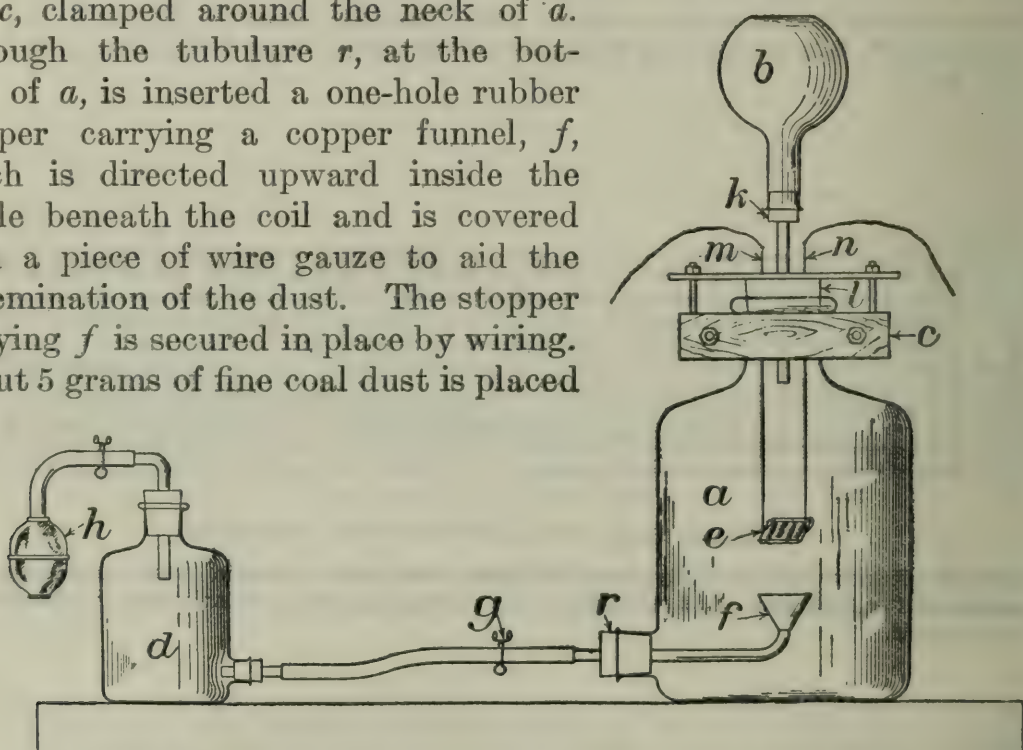


FIGURE 95.—Apparatus for demonstrating the inflammability of coal dust.

in *f*, and the projecting end of *f* is connected to the 2-liter bottle *d* by means of thick-walled rubber tubing. By means of the compression bulb *h* the air in the bottle *d* is put under a pressure of about 450 mm. of mercury. The platinum coil, the source of ignition, is heated for about 10 minutes by a current of 6.5 amperes, when the air in *a* is warm. The dust in *f* is then suddenly ejected by opening the pinch cock *g*. When the dust is ejected, *a* is filled with flame, and a loud report follows, caused by the explosion of the flask.

The experiment is performed with safety only when the bottle *a* and flask *b* are inclosed in a heavy box with a thick plate-glass front, otherwise injury may be caused by the projected pieces of glass.

PUBLICATIONS ON MINE ACCIDENTS AND METHODS OF MINING.

The following Bureau of Mines publications may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C.:

BULLETIN 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls., 4 figs.

BULLETIN 15. Investigations of explosives used in coal mines, by Clarence Hall, W. O. Snelling, and S. P. Howell, with a chapter on the natural gas used at Pittsburgh, by G. A. Burrell, and an introduction by C. E. Munroe. 1911. 197 pp., 7 pls., 5 figs.

BULLETIN 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 61 pp., 10 pls., 12 figs. Reprint of United States Geological Survey Bulletin 423.

BULLETIN 20. The explosability of coal dust, by G. S. Rice, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. 204 pp., 14 pls., 28 figs. Reprint of United States Geological Survey Bulletin 425.

BULLETIN 44. First national mine-safety demonstration, Pittsburgh, Pa., October 30 and 31, 1911, by H. M. Wilson and A. H. Fay, with a chapter on the explosion at the experimental mine by G. S. Rice. 1912. 75 pp., 7 pls., 4 figs.

BULLETIN 45. Sand available for filling mine workings in the Northern Anthracite Coal Basin of Pennsylvania, by N. H. Darton. 1912. 33 pp., 8 pls., 5 figs.

BULLETIN 46. An investigation of explosion-proof mine motors, by H. H. Clark. 1912. 44 pp., 6 pls., 14 figs.

BULLETIN 48. The selection of explosives used in engineering and mining operations, by Clarence Hall and S. P. Howell. 1913. 50 pp., 3 pls., 7 figs.

TECHNICAL PAPER 6. The rate of burning of fuse as influenced by temperature and pressure, by W. O. Snelling and W. C. Cope. 1912. 28 pp.

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TECHNICAL PAPER 18. Magazines and thaw houses for explosives, by Clarence Hall and S. P. Howell. 1912. 34 pp., 1 pl., 5 figs.

TECHNICAL PAPER 19. The factor of safety in mine electrical installations, by H. H. Clark. 1912. 14 pp.

TECHNICAL PAPER 21. The prevention of mine explosions; report and recommendations, by Victor Watteyne, Carl Meissner, and Arthur Desborough. 12 pp. Reprint of United States Geological Survey Bulletin 369.

TECHNICAL PAPER 22. Electrical symbols for mine maps, by H. H. Clark. 1912. 11 pp., 8 figs.

TECHNICAL PAPER 24. Mine fires, a preliminary study, by G. S. Rice. 1912. 51 pp., 1 fig.

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MINERS' CIRCULAR 3. Coal-dust explosions, by G. S. Rice. 1911. 22 pp.

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